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LINK AVAILABILITY AND RAIN ATTENUATION EXCEEDANCE CHARACTERISTICS FOR EHF SATELLITE COMMUNICATIONS WITH ARBITRARY LINK PARAMETERS IN CANADA (U)

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by

S.M. Khanna and D.M. Adams

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DEFENCE RESEARCH ESTABLISHMENT OTTAWA
REPORT NO. 991

October 1988
Ottawa

Canada

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ABSTRACT

The rain attenuation exceedance and the corresponding link availability have been calculated for any location in Canada for a Satcom link in the 10-45 GHz range with arbitrary values of the link parameters. Contours, with arbitrary constant values, of these two parameters are also determined for any region in Canada. The effect of site diversity on these results can be studied. The results are presented in different formats to facilitate their use in a system design. The CCIR rain attenuation prediction model, Hodge site diversity model and long term rain statistics have been used for this work. Following a brief review of the subject, representative rain attenuation exceedance and link availability results are given for a Satcom link at 20, 30 and 44 GHz for a few selected values of the link parameters. From the point of view of rain attenuation, this study indicates the feasibility of a 20-44 GHz Satcom system for Canada with ~ 99.5% link availability.

RESUME

L'atténuation excédentaire due à la pluie ainsi que la disponibilité correspondante de liaison radio par satellite, opérant sur une plage de fréquences de 10 à 45 GHz et utilisant des paramètres de liaisons arbitraires, ont été calculés pour toutes les régions du Canada. Les contours de ces paramètres à valeurs constantes ont aussi été déterminés pour ces régions. Les effets de communications simultanées, utilisant la diversité d'emplacement sur ces résultats ont été étudiés. Les résultats sont présentés sous différents formats afin de faciliter leur utilisation pour la conception d'un système de communications par satellite. Le modèle du CCIR pour la prédiction de l'atténuation due à la pluie de même que le modèle de diversité d'emplacement de Hodge et les statistiques à long terme sur la pluie au Canada ont été utilisés pour ce travail. Après une brève revue du sujet, des résultats représentatifs de l'atténuation due à la pluie et de disponibilité de liaison par satellite au Canada, sont donnés pour un système de communications par satellite opérant aux fréquences de 20, 30 et 44 GHz pour certaines valeurs de paramètres de liaison. Du point de vue de l'atténuation due à la pluie, cette étude démontre qu'il est possible de concevoir un système de communications EHF par satellite au Canada ayant une disponibilité de liaison radio près de 99.5%.

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EXECUTIVE SUMMARY

The purpose of this paper is to determine the feasibility of a 20-44 GHz satellite communications (SATCOM) system for Canada from the viewpoint of rain attenuation. The transmitted electromagnetic wave at frequencies above 10 GHz is severely attenuated by rain during its passage through the earth's atmosphere. Rain attenuation is a random process due to the unpredictability of rain occurrence. Hence, statistical methods are used to evaluate the problem.

A brief review of radio wave attenuation in an earth-space path is presented, followed with the details of the rain attenuation prediction method used for this work. Accurate rainfall rate statistics are important for the prediction of rain attenuation. Previously, Canada was divided into a small number of climate regions with a specific rainfall rate for each region. This gave rather poor attenuation statistics averaged over large areas for each zone. In the present work, experimental rain statistics of approximately 500 station years from 47 weather stations in various parts of Canada have been used. It should be noted that the high rainfall rates are limited to a few regions. In fact, rain statistics in Northern Canada are similar to those in a desert.

From the present work, one can calculate, for a wide range of probabilities, the rain attenuation statistics for an arbitrary location within most of the Canadian territory for any geostationary satellite link at any frequency in the 10-45 GHz frequency range. Representative results in the form of tables and contours of rain attenuation statistics are included for SATCOM links at 20, 30 and 44 GHz. Except for the few regions with high rainfall rates, rain attenuation is not a formidable problem for SATCOM in this frequency range. From the point of view of rain, this study indicates the feasibility of a 20-44 GHz SATCOM system for most of Canada with approximately 99.5% link availability.

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LIST OF SYMBOLS

A	Rain attenuation of a radio wave; (dB)
a	A constant for each site in Equation (33)
$A(R)$	Rain attenuation over an "effective earth-satellite path" corresponding to a ground station location with rain rate R; (dB)
A_s	Free space attenuation of an electromagnetic wave; (dB)
Av	Availability of a communication system expressed as a percentage of time of an average year; (%)
A_θ	Rain attenuation over an earth-space path at an elevation angle θ; (dB)
$A_{0.01}$ (or A_P)	Rain attenuation value exceeded for 0.01% (or P%) of time of an average year; (dB)
$(A_{div})_P$	Rain attenuation value exceeded jointly on two separated earth-space paths for P% of time of an average year; (dB)
a', b	A_P dependent factors in site diversity equation
d	Distance between two receiving stations in site diversity case; (km)
d'	Distance between the receiver and transmitter; (km)
f	Frequency of an electromagnetic wave; (sec^{-1})
G_D	Diversity gain corresponding to a single site attenuation exceedance A_P; (dB)
G_d	A_P dependent factor in diversity gain expression (Eqs. (31) and (32)); (dB)
G_f	f dependent constant in diversity gain expression (Eqs. (31) and (32))
G_θ	θ dependent constant in diversity gain expression (Eqs. (31) and (32))

G_Δ	Δ dependent constant in diversity gain expression (Eqs. (31) and (32))
H	Altitude of a geostationary satellite above equator; (km)
h_0	Altitude of an earth station; (km)
h_R	Rain height for an earth station; (km)
k, k_h, k_v	Constants in the empirical expression rain attenuation (Eqs. (10), (13))
L	Length of a radio wave path in a given rain volume; (km)
L'	Vertical extent of rain for an earth-satellite path; (km)
ℓ	Slant range of the satellite from the earth station; (km)
L_G	Horizontal projection of L_s; (km)
L_s	Slant path length through rain for an earth-satellite path; (km)
L(R)	"Effective path length" through rain for an earth-space path for an earth station location with rain rate R; (km)
LM	Link margin for a Satcom system; (dB)
m	Attenuation coefficient for a given rain volume; (km^{-1})
$n(\varepsilon)d\varepsilon$	Number of rain drops per unit volume with radius in the range $(\varepsilon, \varepsilon+d\varepsilon)$; ($km^{-3}$)
N_o	Empirical constant dependent on distribution; ($km^{-3}\ mm^{-1}$)
P (or P')	Percentage (or probability) of time in an average year when the rain rate exceeds a specified value; (%)
P_0	Probability of exceeding a reference rain rate R_0
P_i	Power of electromagnetic radiation incident on a given medium; (watt)

P_t	Power of electromagnetic radiation after its transmission through a given medium; (watt)
P_{out}	Outage of a communication system expressed as a percentage of time of an average year;(%)
Q_a	Absorption cross-section of a rain drop; (km^2)
Q_s	Scattering cross-section of a rain drop; (km^2)
Q_t	Attenuation cross-section of a rain drop; (km^2)
R	Point rain rate at an earth station; (mm/hr)
R_e	Effective radius of the earth; (km)
R_0	Reference rain rate; (mm/hr)
$R_{0.01}$(or R_P)	Rain rate exceeded for 0.01% (or P%) of time of an average year; (mm/hr)
R'	Radius of the earth; (km)
$r_{0.01}$	Reduction factor corresponding to rain attenuation exceedance for 0.01% of time of an average year
$\alpha, \alpha_h, \alpha_v$	Constants in empirical relation for specific attenuation (Eqs. (10), (14))
β	Angular distance between the ground station and sub-satellite point on the earth's surface; (degree)
γ	Specific attenuation of a rain volume; (dB/km)
$\gamma_{0.01}$	Specific attenuation of a rain volume corresponding to $R_{0.01}$; (dB/km)
Δ	Angle between the line segment joining the two receiving terminals and the ground projection of the earth-space path [10]; (degree)
$\Delta\eta$	Longitude difference between the earth station and sub-satellite point; (degree)
θ	Elevation angle for an earth satellite path; (degree)
Λ	A distribution dependent empirical constant; (mm^{-1})

λ	Wavelength of an electromagnetic wave; (km)
μ	Refractive index of water of the rain drop
ρ	Number of rain drops per unit volume; (km^{-3})
ξ	Longitude of the earth station; (degree)
τ	Polarization tilt angle relative to the horizontal plane; (degree)
ϕ	Latitude of the earth station; (degree)
ε	Radius of the rain drop (mm)

1.0 INTRODUCTION

The propagation characteristics of electromagnetic waves play an important role in the design of space communication systems. Attenuation due to hydrometeors, mainly rain, represents perhaps the most degrading influence suffered by the transmitted wave as it passes through the earth's atmosphere. This is particularly true for satellite communication systems which operate above ~ 10 GHz. Further, the rain attenuation increases with frequency in the 1-100 GHz range. On the other hand, spectral crowding at lower frequencies points out the desirability of moving to higher frequency bands. In particular, greater available bandwidths and the associated higher data rates with improved antijamming characteristics at Extremely High Frequencies (EHF) make this band extremely attractive for military satellite communications.

Clearly, it is necessary to make a compromise between the higher data rates and better antijamming characteristics and the reduction in link availability in EHF communication systems. Since rain will be the primary source of attenuation in most cases, an assessment of rain attenuation is mandatory in the planning stages of such a system. The randomness of rainfall adds further uncertainty and complexity in the radio wave propagation. Hence, statistical approaches are used to evaluate the problem. Thus, the statistical rain data is one of the key parameters in determining the rain attenuation statistics. The Department of National Defence is presently working towards the possible use of EHF satellite communications (Satcom) in the future. Before developing

such a system, it is therefore essential to determine radio wave attenuation due to rain in various parts of Canada at these frequencies. Preliminary work on this subject was done earlier by one of the authors [1].

From the present work, one can calculate the rain attenuation exceedance and the corresponding link availability values at an arbitrary location within most of the Canadian territory for any geostationary satellite link at any frequency in the 10-45 GHz range for a wide range of probabilities. Computer programs have also been developed to plot contours of constant rain attenuation exceedance or link availability with a given link margin for most of the Canadian territory for any combination of the relevant link parameters. In particular, rain attenuation exceedance and link availability data can be determined for 47 locations, with long term rain data records, in various parts of Canada. The results are presented in different formats to facilitate their use in a system design.

2.0 FUNDAMENTALS OF RADIO WAVE PROPAGATION

2.1 Transmission Principles

The power density of an electromagnetic wave at a point is inversely proportional to the square of the distance between the source and that point. Free space transmission loss expressed in decibels between two points in a radio link is given by

$$A_s = 20 \log\left(\frac{4\pi d'}{\lambda} \right) \quad \text{(dB)} \ldots\ldots (1)$$

where A_s is the free-space attenuation in decibels, λ is the

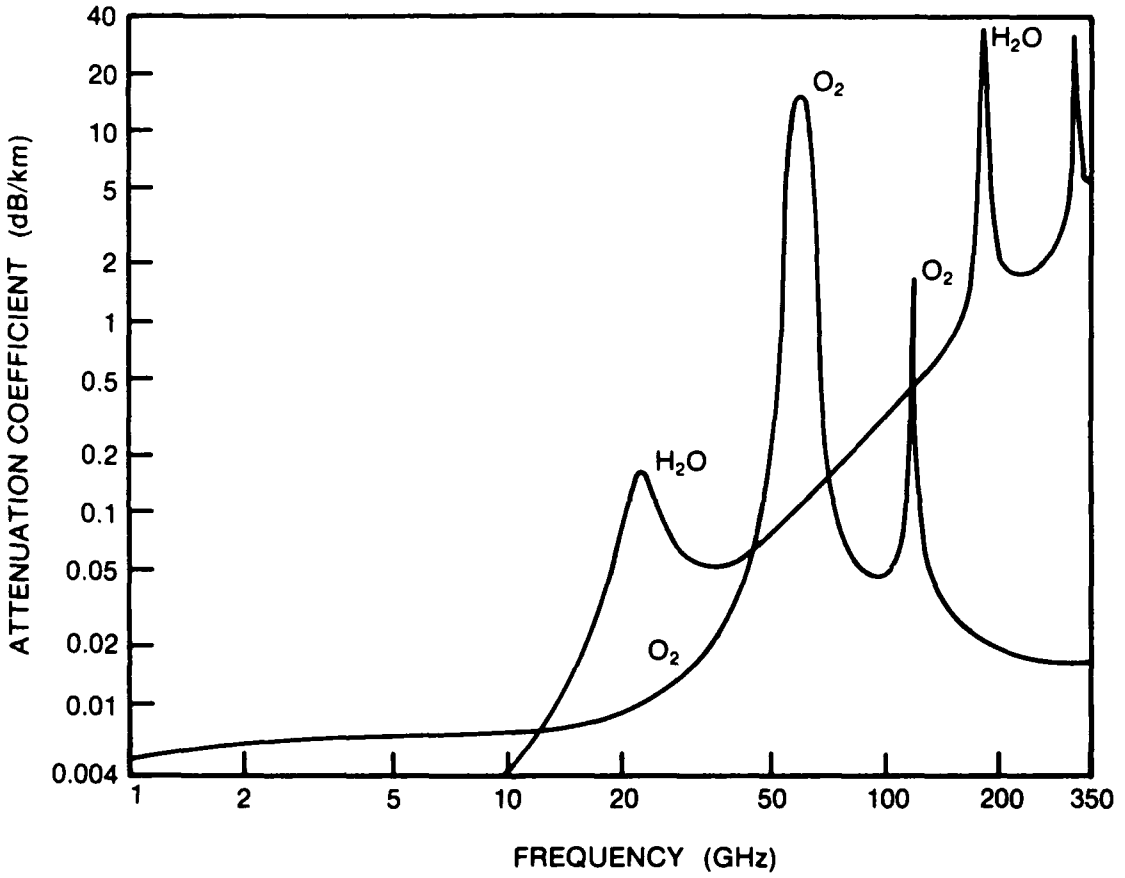

Fig. 1 Attenuation coefficients for oxygen and water vapor at a pressure of 1 atm., a temperature of 20° C and a water vapor density of 7.5 g/m^3 [3].

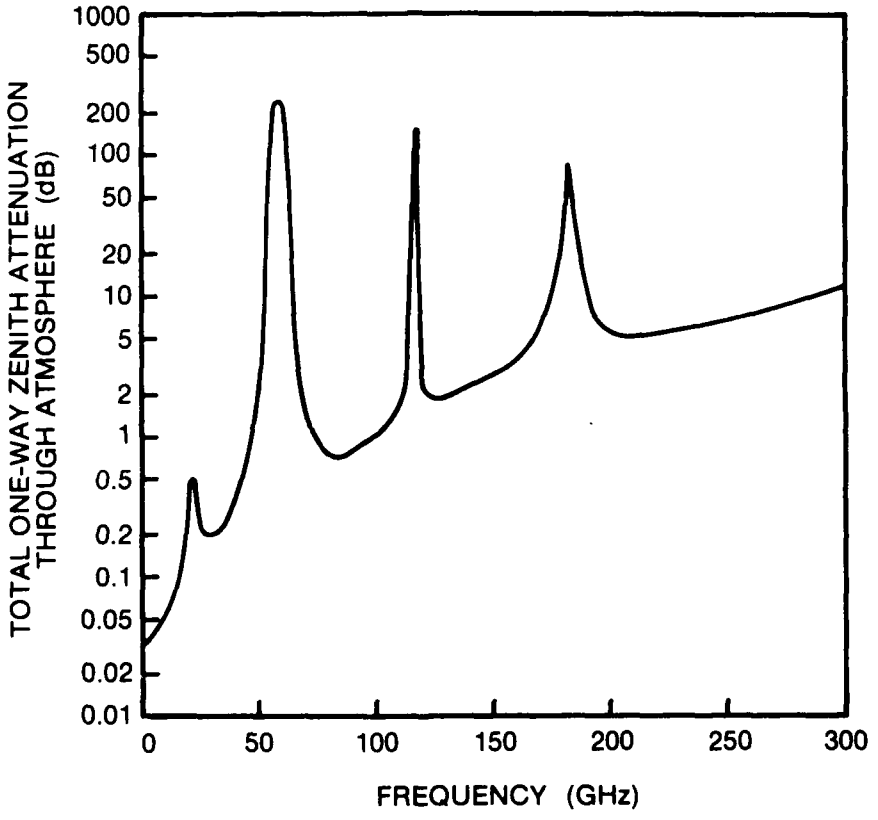

Fig. 2 Total one-way zenith attenuation through the atmosphere with moderate humidity (7.5 g/m^3 at the sufrace) as a function of frequency [3].

wavelength and d' is the distance between the receiver and the transmitter. This attenuation is always present when radio waves propagate in free space or in regions whose characteristics approximate the uniformity of free space such as the earth's atmosphere.

In addition, there are several other factors which influence radio wave propagation [2,3]. The frequency of the radio wave is a critical factor in determining the attenuation or modification of the radio wave. Ionospheric effects tend to become less significant as the frequency of the wave increases and above about 3 GHz the ionosphere is essentially transparent to space communications with some notable exceptions. On the other hand, gaseous constituents of the earth's atmosphere, primarily oxygen and water vapor, interact with the radio wave. This interaction is particularly intense over certain frequency bands corresponding to the absorption bands of oxygen and water vapor. Practical earth-space communication has been mainly developed in the atmospheric windows between these absorption bands. Fig. 1 shows the attenuation coefficient vs. frequency for oxygen and water vapor at a humidity of 7.5 g/m^3, a pressure of 1 atmosphere and a temperature of 20° C. Fig. 2 shows the total one-way zenith attenuation through the atmosphere vs. frequency for a moderately humid atmosphere (7.5 g/m^3 water vapor density at the surface). For elevation angles in the range of 15°-90°, the gaseous attenuation for a moderately humid atmosphere is below ~ 2 dB for frequencies up to 41 GHz. There are several other effects of the non-ionized atmosphere, the ionosphere and the extra terrestrial ionized media on the propagating radio wave.

Some of the factors affecting the radio wave propagation are:

- Attenuation by hydrometeors and atmospheric gases;
- Depolarisation by hydrometeors and Faraday rotation;
- Noise emission due to gases and hydrometeors;
- Scintillation of amplitude and phase caused by turbulence or refractive index irregularities;
- Loss of signal due to beam-divergence of the earth-station antenna due to normal refraction in the atmosphere;
- A decrease in effective antenna gain due to phase decorrelation across the antenna aperture;
- Possible limitations in bandwidth due to multiple path effects or multiple scattering, specially in high data rate systems.

At EHF frequencies, hydrometeors are the dominant source of attenuation although other factors like scintillation fading at low angles of elevation may also be quite significant. Henceforth, this work deals only with hydrometeor attenuation in satellite communications.

3.0 HYDROMETEOR ATTENUATION IN SATELLITE COMMUNICATIONS

Hydrometeors in the radio wave path can produce major impairments to space communications. Hydrometeors refer to products of condensed water vapor in the atmosphere and include rain, hail, cloud, fog, ice or snow. Rain is the major source of impairment of the radio wave. Attenuation due to water cloud or fog can be calculated if the liquid water content is known. Except for clouds of high water content, attenuation due to clouds is generally equivalent to light rainfall attenuation. The effects of dry hail and dry snow

can be generally neglected at the EHF frequencies.

A brief description of the classical development for the determination of rain attenuation is provided next. The attenuation A of a radio wave propagating in a volume of rain of length L in the direction of wave propagation can be expressed as

$$A = \int_0^L \gamma \, dx \qquad \text{(dB).....(2)}$$

where γ is the specific attenuation (dB/km) of the rain volume. In the classical development, it is assumed that the intensity of the wave decays exponentially as it propagates through the volume of rain. Thus, the incident power P_i of a wave incident on a volume of uniformly distributed water drops extending over the length L and the transmitted power P_t after its passage through the medium are given by

$$P_t = P_i \, e^{-mL} \qquad \text{(watt).....(3)}$$

where m is the attenuation coefficient for the rain volume expressed in units of reciprocal length. The attenuation of the radio wave expressed as a positive decibel value is given by

$$A = 10 \log_{10}\left(\frac{P_i}{P_t} \right) = 4.343 \, mL \qquad \text{(dB)....(4)}$$

The attenuation coefficient m can be expressed as

$$m = \rho \, Q_t \qquad (km^{-1}).....(5)$$

where ρ is the number of drops per unit volume and Q_t, the attenuation cross-section of the drop, expressed in units of area, is the sum of a scattering cross-section Q_s and an absorption cross-section Q_a. Q_t is a function of drop radius

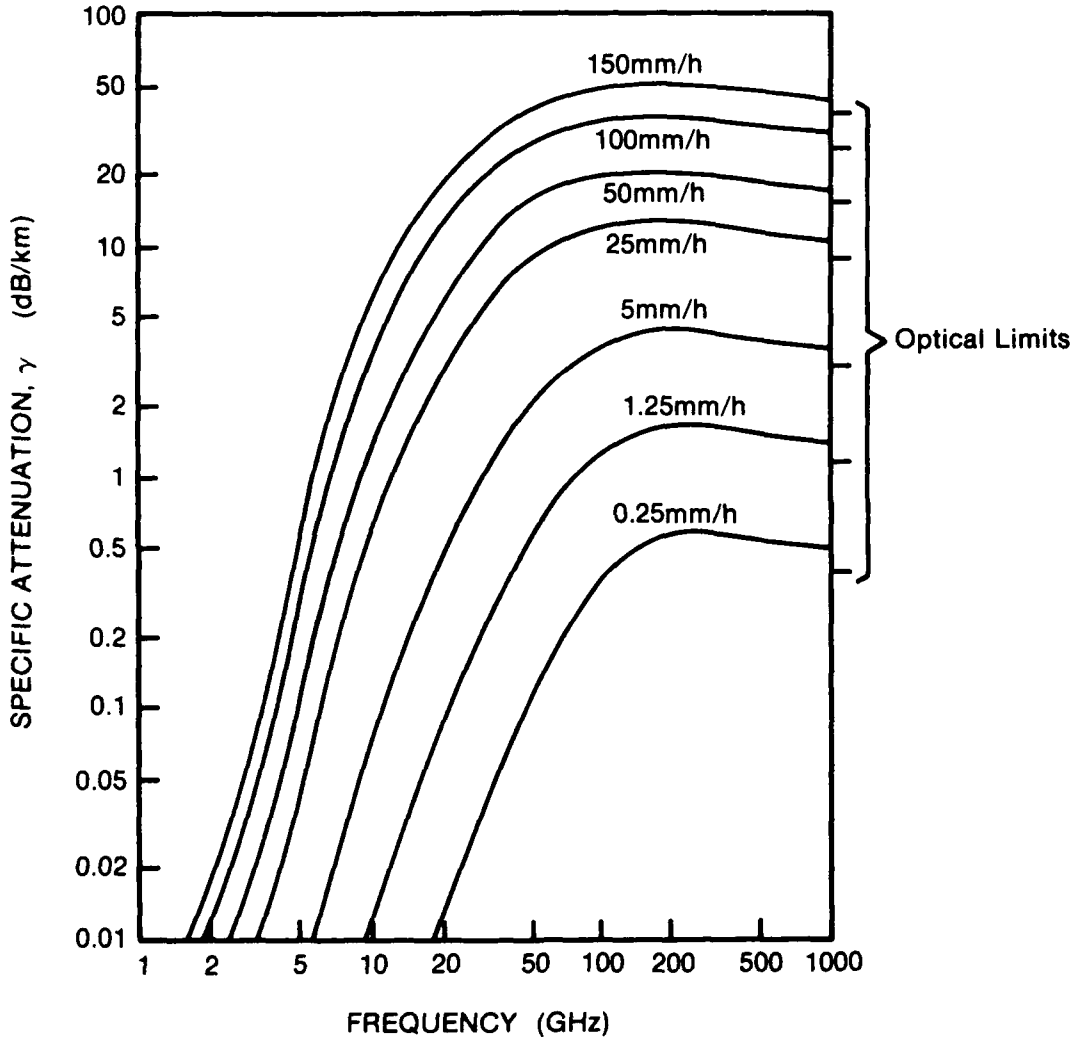

Fig. 3 Specific attenuation γ due to rain as a function of frequency for various rain rates [7].

ε, wavelength λ of the radio wave and complex refractive index μ of the water drop. If the drops do not have the same radius, the attenuation coefficient m is determined by integrating over all drop radii. Thus, Eq. (5) is modified to

$$m = \int Q_t(\varepsilon,\lambda,\mu)\ n(\varepsilon)\ d\varepsilon \qquad (km^{-1}).....(6)$$

where $n(\varepsilon)d\varepsilon$ gives the number of drops per unit volume with radius in the range $(\varepsilon, \varepsilon+d\varepsilon)$. The specific attenuation γ, expressed in dB/km, is obtained from Eqns. (4) and (6) with L = 1 km. Thus,

$$\gamma = 4.343\ m = 4.343 \int Q_t(\varepsilon,\lambda,\mu)n(\varepsilon)\ d\varepsilon \quad (dB/km).....(7)$$

Thus, the specific attenuation γ depends on attenuation cross-section, rain drop size and drop size distribution. The latter two parameters are a function of rain structure only whereas Q_t depends on frequency and temperature also. All of these parameters are not directly predictable and hence statistical methods are used. Q_t can be obtained by employing the Mie classical scattering theory for a plane wave radiation on an absorbing sphere. The distribution of rain drop sizes $n(\varepsilon)$ can be represented in terms of the drop radius ε (mm) and two empirical constants N_o and Λ determined from the distribution. The constant Λ, in turn, is dependent on rain rate R (mm/hr). Thus, the specific attenuation γ is dependent on the physical properties of water as well as the characteristics of rain structure and is given by

$$\gamma = 4.343\ N_o \int Q_t(\varepsilon,\lambda,\mu)\ e^{-\Lambda\varepsilon}\ d\varepsilon \qquad (dB/km).....(8)$$

The specific attenuation γ can now be calculated as a function of frequency, refractive index and drop size distribution. Fig. 3 shows specific attenuation γ vs. frequency f at various rain rates for the drop size distribution of Laws

and Parsons [4] at a rain temperature of 20° C. The total rain attenuation A for a path of length L is obtained by using this value of γ in Eq.(2). Thus,

$$A = 4.343 \int_0^L \left(N_o \int Q_t \, e^{-\Lambda\varepsilon} \, d\varepsilon \right) dx \quad (dB) \ldots\ldots(9)$$

The relationship between specific attenuation γ and rain rate R at the ground station can be approximated by [5]

$$\gamma = kR^{\alpha} \qquad (dB/km) \ldots\ldots(10)$$

where k and α are frequency, temperature and polarization dependent constants. The parameters k, α and R represent approximately the complicated dependence of γ on frequency, temperature and drop size distribution. Eq.(10) is used in virtually all models for the prediction of path attenuation from rain rate at a point.

3.1 Slant Path and Elevation Angle Dependence

The rain attenuation A_θ over an earth-satellite slant path at an elevation angle θ is given by

$$A_\theta = \frac{L'\gamma}{\sin\theta} = \frac{L'kR^{\alpha}}{\sin\theta} \qquad (dB) \ldots\ldots(11)$$

where L′ is the vertical extent of rain. The main problem in determining the slant path attenuation is in finding the extent of the slant path length and the rain rate profile along that path. The main effort in developing the attenuation prediction models has been to relate the attenuation along the path with measurable quantities such as the 0° C isotherm height and the rainfall rate at the ground station.

In general, the prediction models utilize the measured rain rate at the ground station as the statistical

variable and use Eq.(10) to calculate the specific attenuation. The attenuation from these prediction models can thus be expressed as

$$A(R) = kR^{\alpha} L(R) \quad (dB) \qquad .....(12)$$

where L(R) is an "effective path length" for the earth-space path. It is this L(R) and γ which determine an attenuation distribution A(R) from a specified rain rate distribution. The major difference between the various prediction methods is in their approach to determine an "effective path length" parameter L(R).

3.2 The CCIR Rain Attenuation Prediction Method

The International Radio Consultative Committee (CCIR) has recommended a method to predict rain attenuation statistics for an earth-space path from point rain rate distribution [6]. This model has been used for the present work. In this model, the attenuation exceeded for 0.01% of an average year, $A_{0.01}$, is calculated first. The attenuation exceeded for other percentages of an average year, in the range of 0.001% to 1.0%, can then be calculated from $A_{0.01}$. The following input parameters are needed to calculate the slant-path rain attenuation statistics at a given location:

$R_{0.01}$ (mm/hr)	:	the point rainfall rate that is exceeded for 0.01% of the average year at the location;
h_0 (km)	:	the height of the earth station above sea level;
θ (degree)	:	the elevation angle;
ϕ (degree)	:	the latitude of the earth station;
ξ (degree)	:	the longitude of the earth station.

In addition, information regarding the satellite location and link frequency is also required.

As mentioned earlier, the specific attenuation depends on rain rate and is given by

$$\gamma = kR^{\alpha} \quad (dB/km) \qquad .....(10)$$

For linear and circular polarization, the coefficients k and α can be calculated using the following equations [7]:

$$k = \frac{1}{2}\left[k_h + k_v + (k_h - k_v)\cos^2\theta \cos 2\tau \right] \qquad .....(13)$$

$$\alpha = \frac{1}{2k}\left[k_h\alpha_h + k_v\alpha_v + (k_h\alpha_h - k_v\alpha_v) \cos^2\theta \cos 2\tau \right] \qquad ...(14)$$

where τ is the polarization tilt angle relative to the horizontal. $\tau = 45°$ for circular polarization. Thus, for circular polarization, the above equations simplify to

$$k = \frac{1}{2}\left[k_h + k_v \right] \qquad .....(15)$$

$$\alpha = \frac{1}{2k}\left[k_h\alpha_h + k_v\alpha_v \right] \qquad .....(16)$$

The constants k_h, k_v, α_h and α_v are tabulated as a function of frequency in the 1-400 GHz range in a CCIR Report [7]. At intermediate frequencies, logarithmic scaling is used for frequency, k_h and k_v whereas a linear scaling is used for frequency, α_h and α_v. Knowing k and α at the link frequency, one can calculate

$$\gamma_{0.01} = kR_{0.01}^{\alpha} \quad (dB/km) \qquad .....(17)$$

where $\gamma_{0.01}$ is the specific attenuation that is exceeded for 0.01% of an average year.

The elevation angle θ is given by [8]

$$\text{Cos } \theta = \left[\frac{(R' + H)}{\ell}\right] \text{Sin } \beta \qquad .....(18)$$

where R' is the radius of the earth (6370 km), H (35816 km) is the altitude of a geostationary satellite above the equator, β is the angular distance between the ground station and the sub-satellite point on the earth's surface and ℓ is the slant range of the satellite from the earth station. β and ℓ can be obtained from the following equations:

$$\text{Cos } \beta = \text{Cos } \phi \text{ Cos } \Delta\eta \qquad .....(19)$$

$$\ell = \left[R'^2 + (R' + H)^2 - 2R'(R' + H)\text{Cos } \beta \right]^{1/2} \text{(km)}...(20)$$

where $\Delta\eta$ is the longitude difference between the earth station and the sub-satellite point.

Next, the "effective path length" for the earth-space path through rain has to be calculated. Fig. 4 gives a schematic presentation of such a path. In the present method, the "effective path length" can be calculated through the following steps:

The rain height h_R (km) for a given earth station at latitude ϕ is given by

$$h_R = \begin{cases} 4.0 & 0 < \phi < 36° \\ 4.0 - 0.075\ (\phi - 36) & \phi \geq 36° \end{cases} \text{(km)}.....(21)$$

For $\theta < 10°$, the slant-path length L_s below the rain height is obtained from the equation

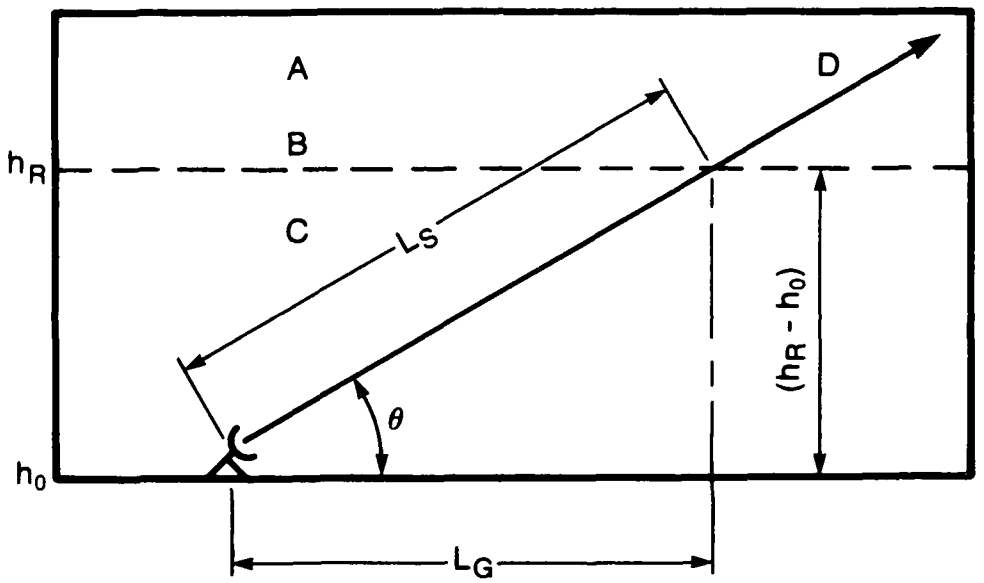

Fig. 4 Schematic presentation of an Earth-space path for satellite communication.

A : Frozen precipitation;
B : Rain level;
C : Rain region;
D : Earth-space path from a ground station to a satellite;
(h_R-h_0) : Rain height above the ground station.

$$L_s = \frac{2(h_R - h_0)}{\left(\sin^2\theta + \frac{2(h_R - h_0)}{R_e} \right)^{1/2} + \sin\theta} \quad (km) \quad .....(22)$$

where R_e is the effective radius of the earth (8500 km). For $\theta \geq 10°$, this equation simplifies to

$$L_s = \frac{(h_R - h_0)}{\sin\theta} \quad (km) \quad .....(23)$$

The horizontal projection, L_G, of the slant-path length is found from (see Fig. 4)

$$L_G = L_s \cos\theta \quad (km) \quad .....(24)$$

For 0.01% of the year, the reduction factor $r_{0.01}$, which takes into account the nonuniformity of rain rate along the slant path, can be obtained from

$$r_{0.01} = \frac{90}{90 + 4L_G} \quad .....(25)$$

The attenuation $A_{0.01}$ exceeded for 0.01% of an average year is then calculated from

$$A_{0.01} = \gamma_{0.01} L_s r_{0.01} \quad (dB) \quad .....(26)$$

The attenuation A_P exceeded for other percentages P of an average year, in the range of 0.001% to 1.0%, may be estimated from $A_{0.01}$ by using the following equation

$$\frac{A_P}{A_{0.01}} = 0.12\, P^{-(0.546 + 0.043 \log P)} \quad .....(27)$$

The above equation can be rearranged to yield yearly outage times P_{out} given as percentage of a year. For a given link margin LM (dB), the yearly outage time expressed as a

percentage of an average year is given by

$$P_{out}=10^{\left(-6.349 + \left(40.308 - 23.256 \log \left(\frac{LM}{0.12\ A_{0.01}} \right) \right)^{1/2}\right)} \quad (\%)....(28)$$

Hence, the availability Av expressed as a percentage of time of an average year is

$$Av = 100 - P_{out} \quad (\%)....(29)$$

For latitudes above 30° , this CCIR method has been reported to predict $A_{0.01}$ to within 10% with a standard deviation of 30% when simultaneous rain rate measurements were used [6]. As far as is known to the authors, this model has not yet been tested at EHF frequencies for the Canadian conditions.

3.3 Site Diversity Gain Model

Hodge [9] has proposed a diversity gain model to calculate the diversity gain G_D using a number of parameters. This model was incorporated into the CCIR prediction model to provide an option of calculating the rain attenuation statistics with space diversity. The diversity gain G_D is given by

$$G_D(A_P) = A_P - (A_{div})_P \quad (dB).....(30)$$

where A_P and $(A_{div})_P$ are the attenuation values exceeded on a single path and that exceeded jointly on separated paths respectively for a given percentage of time. According to this model,

$$G_D = G_d\ G_f\ G_\theta\ G_\Delta \quad (dB).....(31)$$

where each factor contains the dependence of the variable de-

noted by its subscript. Here d is the separation distance between the two earth stations, A_p is the single-site attenuation, f is the link frequency, θ is the elevation angle and Δ is the earth terminals baseline to path angle which is defined as the positive angle made between the line segment joining the two receiving terminals and the ground projection of the earth-space path [10]. Δ is measured in such a way that it is always less than 90°. The factors in Eq. (31) are given by

$$\left.\begin{aligned} G_d &= a\left(1-e^{-bd}\right) && \text{(dB)} \\ a &= 0.64A_p - 1.6\left(1- e^{-0.11A_p}\right) && \text{(dB)} \\ b &= 0.585\ \left(1-e^{-0.98A_p}\right) && (\text{km}^{-1}) \\ G_f &= 1.64\ e^{-0.025f} \\ G_\theta &= 0.00492\ \theta + 0.834 \\ G_\Delta &= 0.00177\ \Delta\ +\ 0.887 \end{aligned}\right\} \quad ..(32)$$

Here d is in km, A_p is in dB, f is in GHz and θ and Δ are in degrees. This model gives good agreement with experimental measurements when single site attenuation is below ~11 dB. For higher values of A_p , the agreement is not so good.

4.0 RAIN RATE STATISTICS FOR CANADA

There are two databases which provide information on probability vs. rainfall rate exceedance for use in the present work. Details of these databases are described in this Section.

Segal [11] analysed the tipping-bucket rain gauge data of ~ 500 station years from 47 stations in various parts of Canada. Fig. (5) gives the locations of these precipita-

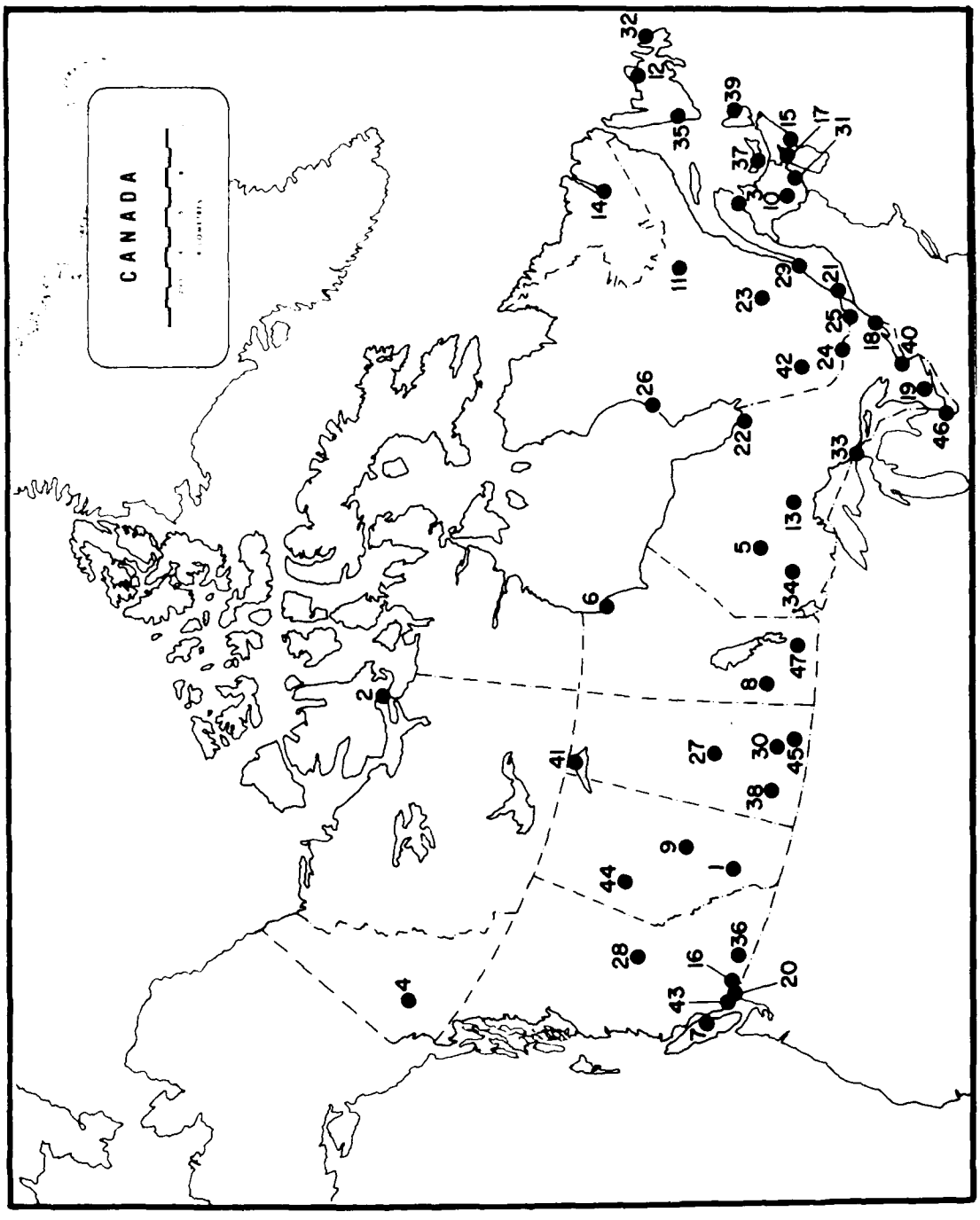

Fig. 5 Map showing the locations of precipitation recording stations from which rain data have been used in this work. The numbers correspond to the station listings in Tables 1 and 2 [11].

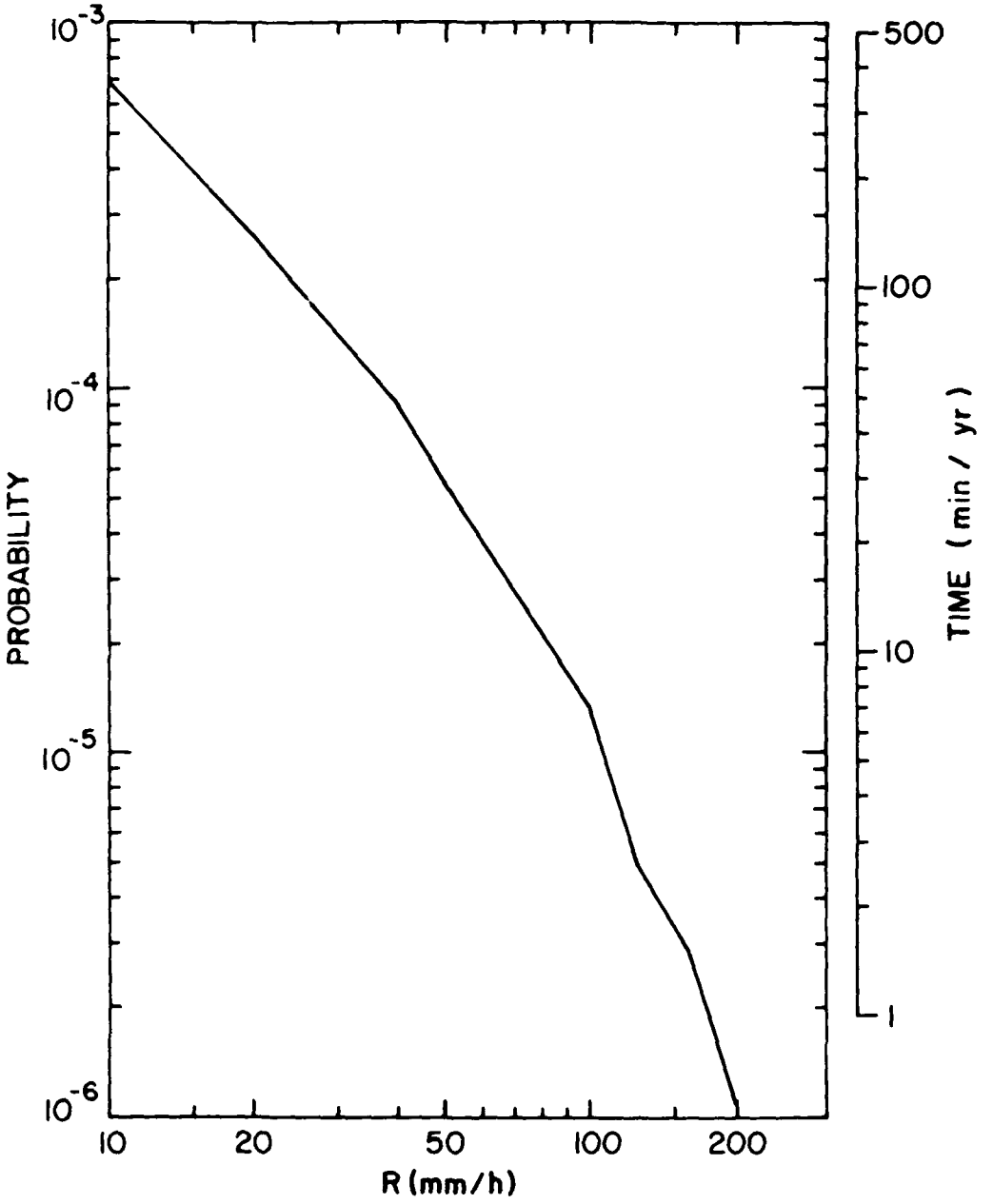

Fig. 6 Long term average probability of exceeding a given rainfall rate at Ottawa, Ont. [11].

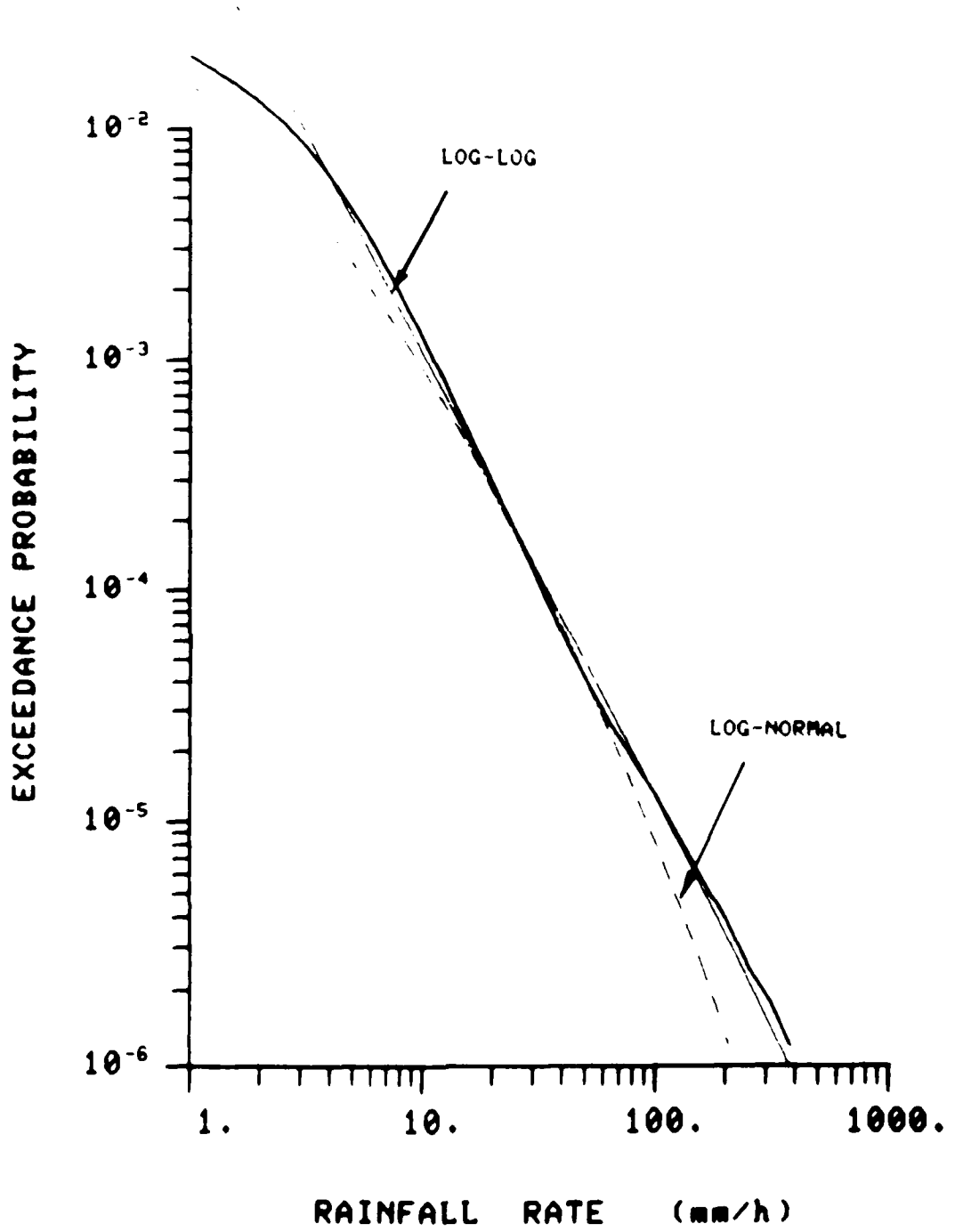

Fig. 7 A typical rainfall distribution curve at one of the rain recording stations with log-log and log-normal approximations [11].

tion recording stations. An example of the typical experimental results of probabilitiy of exceeding a given rainfall rate at one of these stations is given in Fig. (6).

Segal noted that the probability P' that a given rain rate R is exceeded at a site can be approximated by a power law relationship

$$P' = P_0 \left(\frac{R}{R_0} \right)^a \qquad .....(33)$$

where P_0 is the probability of exceeding a reference rain rate R_0. This power law is in good agreement with the experimental results for values of R exceeding ~ 2-3 mm/hr. Fig. 7 shows an example of such a power law fit to the experimental rainfall rate data. Knowing a, P_0 and R_0, the rainfall rate exceedance at the site can be calculated as a function of P'. Thus, P_0 and a are important parameters for any location.

Segal [12] calculated a and P_0 values for the 47 locations for R_0 = 100 mm/hr from experimental rainfall rate data at these sites. This data is identified as the "city database" and is used in the rain attenuation prediction programs for these locations. For ready reference, this data is also included in Table 1. The altitude, latitude and longitude for these stations are given in Table 2 [11]. Using the calculated values of the parameters a and P_0 for the 47 sites, Segal [11] determined contours of a and P_0 for various values of these parameters for most parts of Canada (Figs. 8-9). The contours do not extend into the far North or into the Atlantic or Pacific ocean due to lack of reliable data. Lack of data in the West Coast region is due to uncertainty and rapid variations in precipitation characteristics in mountainous regions.

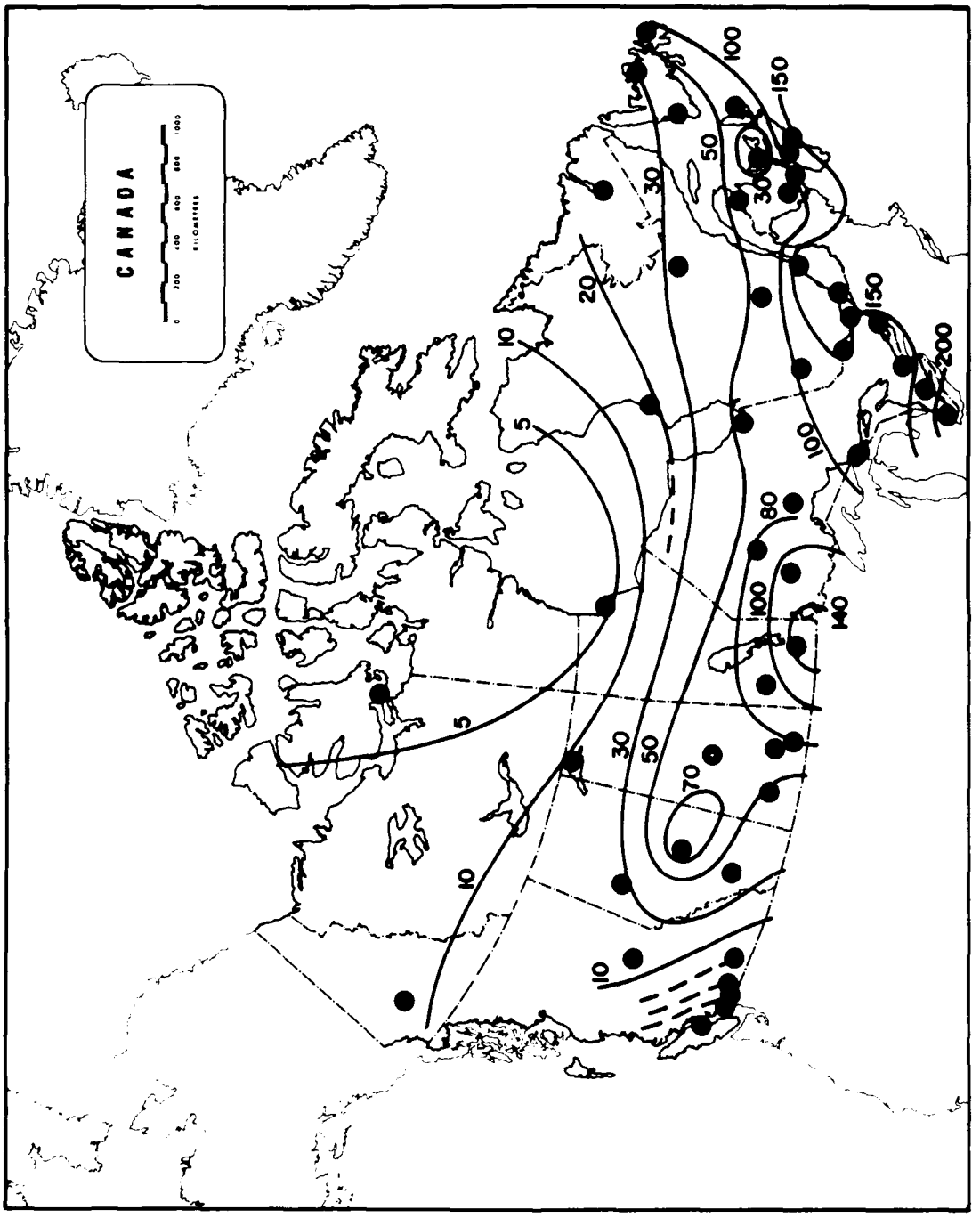

Fig. 8 Contours of constant P_0. The numerical value beside each curve equals 10^7 P_0. The locations of the rain recording stations are indicated [11].

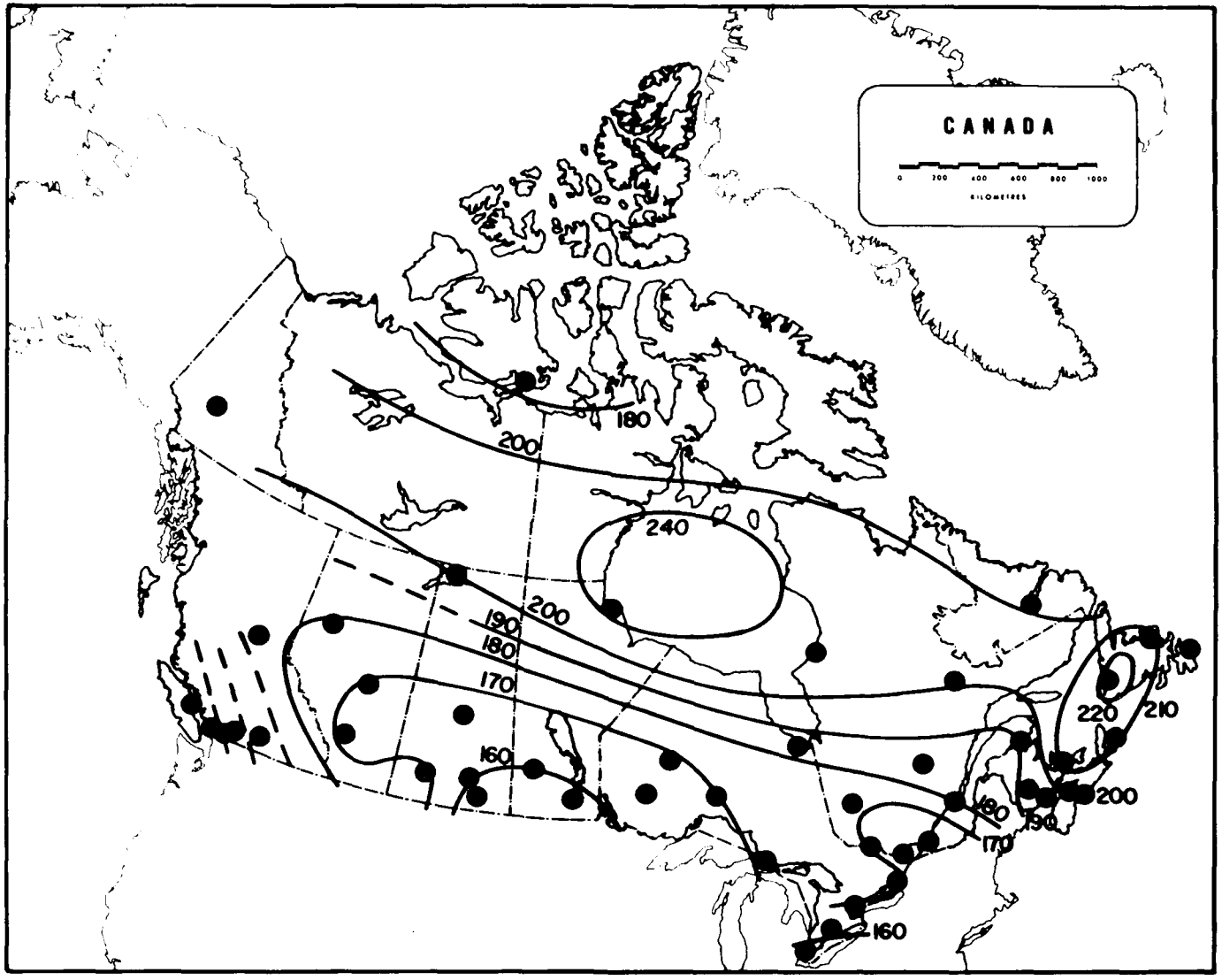

Fig.9 Contours of constant a. The numerical value beside each curve corresponds to -100a. The locations of the recording stations are indicated [11].

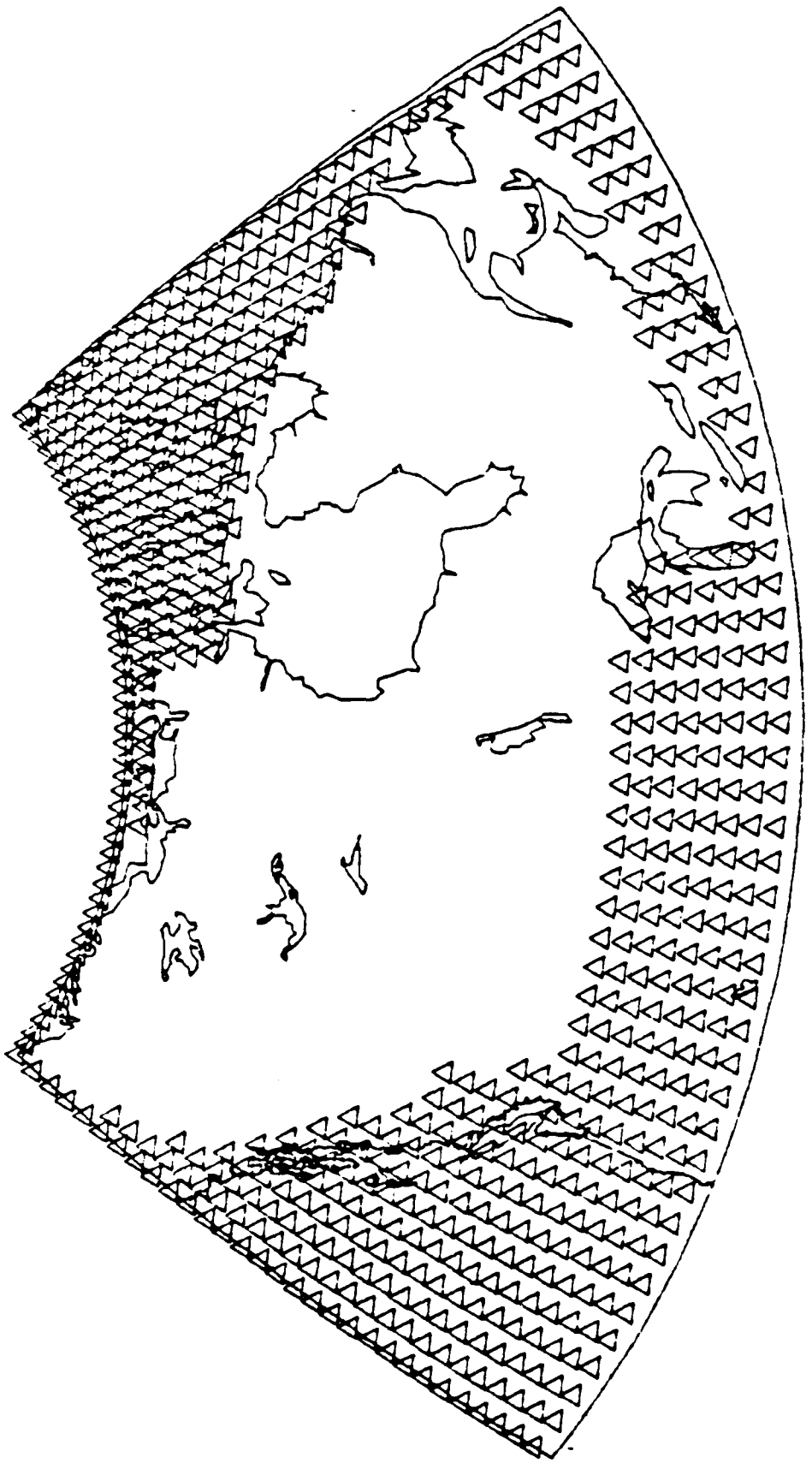

Fig. 10 Unshaded region in this map indicates the part of Canada for which rain rate data and rain attenuation statistics are available.

For rainfall rate distribution at an arbitrary location in Canada, Strickland [13] digitized the above-mentioned contours of a and P_0 (see Figs. 8-9) at intervals of 1° in latitude and 2° in longitude. The data were digitized from 42° to 70° in latitude and 143°W to 55°W in longitude and the parameters a and P_0 were determined for all points on the grid. These data were stored in a subroutine and constitute the second of the two databases. This database is used in the prediction programs to determine rain attenuation at an arbitrary location in Canada. The unshaded area in Fig. (10) indicates the part of Canada where rainfall rate statistics are available in this manner.

5.0 RAIN ATTENUATION PREDICTION PROGRAMS

In the present work, prediction programs have been developed and results for (i) rain attenuation exceedance for any P and (ii) link availability for any link margin are now available over an earth-satellite path in an EHF geostationary satellite link for most locations in Canada below 70°N (Fig. 10). The CCIR model and the Hodge Site Diversity model have been used for this purpose. The two data bases discussed earlier provide the required rain rate distribution. Details of the two programs developed in the present work are described now in terms of user input and sample outputs.

For the sample results included in this report, the satellite longitude has been arbitrarily set at 100° W. The altitude, h_0, of the ground station site is assumed to be zero except for the locations in the "city database". In the latter cases, the altitude of the site has been taken into account. All of the results can be calculated with or without site diversity. The sample results included in this report correspond to the no site diversity case.

5.1 CANSLAM

"CANSLAM" stands for Canadian Satellite Link Attenuation Mapper. This program generates attenuation maps in three different styles for any input values assigned to the following satellite and network parameters:

- Probability P, expressed as a percentage of an average year in 0.001% to 1.0% range, of exceedance of the calculated attenuation;
- Link frequency f in the 10-45 GHz range;
- Satellite longitude in 40°W- 150°W range;
- Site diversity characteristics.

The results are available in following three formats:

In one format, contours over which attenuation exceeds the given values are plotted on a map of Canada. Figs. 11-19 give rain attenuation exceedance contours for Canada at 20, 30 and 44 GHz for three values of P. Five arbitrary attenuation exceedance values can be specified for these contours on one map. These contours can be plotted for the whole or a part of Canada. It is also possible to determine such contours either for a user specified region or for a preselected region . For convenience, three regions, Eastern Canada, Central Canada and the Prairie Provinces, have been defined. Figs. 20-39 show attenuation exceedance contours for such regions at 20, 30 and 44 GHz for the indicated values of P.

In an alternate presentation, the attenuation exceedance results are displayed in a latitude/longitude table without displaying any geographical boundaries. Two substyles are available: (1) Numerical Table, (2) Symbol Map. In a Numerical Table , attenuation exceeded for a specified percentage of time of an average year is displayed at every degree of latitude and at every two degrees of longitude for a region which is 14 degrees wide in latitude and 18 degrees

wide in longitude. The user specifies the central point of the region through its latitude/longitude coordinates and the program builds a data table around that point. Tables 3-50 give attenuation exceedance results for two values of P at 20, 30 and 44 GHz. Attenuation values of -1 or 0 are displayed for locations for which rain information is not available.

Alternatively, cross-Canada coverage, in contrast to a limited region coverage, giving attenuation exceeded values is available through a Symbol Map. Data presentation capability is however limited in this mode. Here, each symbol represents a range of attenuation values in contrast to the actual attenuation exceeded value depicted in the Numerical Tables. Figs. 40-48 give attenuation exceedance map for Canada for three values of P at 20, 30 and 44 GHz.

In the third format, the attenuation levels exceeded for a specified percentage of time are calculated for the locations included in the "city database" (see Table 1) in five different regions in Canada. Simplified coarse maps are produced which give the approximate location of each site and the corresponding attenuation exceedance value for the specified percentage of time. Figs. 49-63 give attenuation exceedance values for such locations in different regions in Canada at P = 0.1% of an average year at 20, 30 and 44 GHz.

5.2 CANSLAV

"CANSLAV" is a program that generates one way link availability Av contours with a given link margin LM to overcome rain fade for an earth-satellite path in an EHF geostationary link. These contours can be plotted in two different formats for most of Canada for any combination of the following parameters:

- Link Margin LM in 0-100 dB range to overcome rain fade;
- Link Frequency in the 10-45 GHz range;
- Satellite Longitude in 40°W-150°W range.

In one format, contours with constant values of system availability Av are displayed for the whole or a part of Canada. Figs. 64-66 give link availabilty for Canada at 20, 30 and 44 GHz for the indicated values of link margin. Up to five different availability values can be specified on one map. As in Canslam, it is also possible to determine such results for a user specified region or for a preselected region. For convenience, three regions, Eastern Canada, Central Canada and the Prairie Provinces, have been selected. Figs. 67-78 show link availability contours for such regions at 20, 30 and 44 GHZ for the indicated values of link margin.

In an alternate presentation, probability of system availability is calculated for the locations in five regions in Canada which are included in the "city database". Simplified coarse maps with no geographical boundaries are produced and approximate location of each site is indicated on the map. Figs. 79-93 show link availability for these locations at 20, 30 and 44 GHz for the indicated values of link margin.

6.0 DISCUSSION AND CONCLUSIONS

The main purpose of this work was to assess the extent of rain attenuation for EHF Satcom in Canada. This goal led to the development of a method to determine rain attenuation statistics at most locations below 70° N in Canada for an EHF Satcom system with arbitrary values of the link parameters. Geostationary orbits are assumed for all results in this work. This method is applicable to a system with non geostationary orbits also provided the elevation angle is calculated independently for each position of the satellite. The present work is directly applicable to the EHF Satcom system which is being studied currently for the

Department of National Defence. The representative results included in this report are only meant to give an idea of the range of attenuation levels encountered in various parts of the country.

It is clear from these results that an EHF Satcom system is quite feasible for Canada from the point of rain attenuation. This is because the high rainfall rates are limited to the Eastern region and a part of the Central region of the country. As a result, in general, the rain attenuation is high in parts of Eastern and Central Canada and gradually decreases as one moves to Western and Northern Canada. The rainfall rates and rain attenuation are particularly low in Northern Canada.

The system availability values range from low values in parts of Eastern and Central Canada, medium values in Western and most of Central Canada and high values in Northern Canada. For example, with a satellite at 100° W longitude and a link margin of 16 dB, system availability at 44 GHz (see Figs. 66, 75-78) is better than 99.9% of the time of an average year in all regions of the country except in some Eastern and Central areas. In Eastern and Central Canada, maximum attenuation level at 99.5% availability is ~ 11 dB (see Table 35). There is insufficient data for such results for the Western mountains. Similarly, at 20 GHz and a satellite at 100°W, the attenuation exceedance for P = 0.1% is higher than 6 dB in only some parts of Eastern and Central Canada (see Fig.12 and Tables 3,4). Thus, although the rain attenuation increases with frequency at a high rate, it is overall within a manageable range for most of Canada. For high rain rate regions, system diversity would be necessary to achieve higher link availability with feasible values of link margin. Reduction in rain attenuation in such regions can also be obtained by placing the satellite as far to the East as is permitted by other system considerations.

The attenuation exceedance and system availability results for the locations included in the "city database" are relatively more accurate than the corresponding results mentioned elsewhere in the report. This is due to the fact that a and P_0 for these sites were calculated from the experimental rain rate data at those locations rather than from the contours of a and P_0 for the whole country. Further, the altitude of the site is taken into account in the calculations. The calculated rain rate exceedance and the corresponding attenuation results at such sites may, however, still include a small error resulting from the use of the power law approximation to the actual rain rate distribution (see Eq.(33) and Fig.7). Further work is also needed to calculate worst month rain attenuation statistics from these results [14,15].

Using the present work, it is planned to develop a program which will calculate attenuation statistics for a network consisting of a limited number of stations at arbitrary locations in Canada. It would be useful to determine attenuation statistics for the whole network as a function of various system parameters such as satellite longitude, site diversity characteristics, frequency etc. This may be of particular interest in some special applications. Further, it may be possible to determine the rain rate exceedance at any probability for the stations with rain records more accurately than from the power law approximation used in this work. Worst month rain attenuation statistics can also be calculated for these stations.

7.0 ACKNOWLEDGEMENTS

The authors would like to thank Dr. B. Segal, Mr. J.J. Schlesak and Mr. C. Brochu for many helpful discussions pertaining to this work.

8.0 REFERENCES

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TABLE 1

VALUES OF THE PARAMETERS P_0 AND a FOR THE RAINFALL RECORDING STATIONS

	Location	(-a)	(10^7 P_0)	Data Years
1	Calgary, ALTA	1.68	48.02	10
2	Cambridge Bay, NWT	1.760	3.926	5
3	Caplan, QUE	1.815	67.40	9
4	Carmacks, YT	2.11	6.026	10
5	Central Patricia, ONT	1.69	83.34	9
6	Churchill, MAN	2.49	4.764	10
7	Comox, BC	2.72	4.655	10
8	Dauphin, MAN	1.60	83.92	10
9	Edmonton, ALTA	1.70	69.67	10
10	Fredericton, NB	1.695	61.28	10
11	Gagnon, QUE	2.03	33.53	9
12	Gander, NFLD	2.14	26.24	10
13	Geraldton, ONT	1.70	52.15	10
14	Goose Bay, NFLD	1.91	27.24	9
15	Halifax, NS	1.995	148.4	18
16	Hope, BC	3.045	2.764	10
17	Kentville, NS	1.945	97.91	10
18	Kingston, ONT	1.75	104.4	10
19	London, ONT	1.69	187.6	20
20	Mission, BC	2.40	19.02	10
21	Montreal, QUE	1.663	158.6	10
22	Moosonee, ONT	1.84	62.68	6
23	Normandin, QUE	1.87	50.04	10
24	North Bay, ONT	1.70	163.2	10
25	Ottawa, ONT	1.675	151.9	10
26	Poste de la Baleine, QUE	2.115	18.84	5
27	Prince Albert, SASK	1.67	52.56	10
28	Prince George, BC	1.875	28.45	10
29	Quebec, QUE	1.79	160.4	10
30	Regina, SASK	1.65	75.18	20
31	Saint John, NB	1.915	127.2	10
32	St. John's, NFLD	2.075	95.57	10
33	Sault Ste. Marie, ONT	1.71	127.4	10
34	Sioux Lookout, ONT	1.695	118.1	10
35	Stephenville, NFLD	2.21	31.56	7
36	Summerland, BC	2.290	3.288	4
37	Summerside, PEI	2.15	22.05	9
38	Swift Current, SASK	1.74	46.36	10
39	Sydney, NS	2.15	58.14	10
40	Toronto, ONT	1.633	140.9	10
41	Uranium City, SASK	2.00	10.80	10
42	Val d'Or, QUE	1.705	105.4	10
43	Vancouver, BC	2.713	4.818	10
44	Watino, ALTA	1.775	22.83	9
45	Weyburn,SASK	1.51	85.95	10
46	Windsor, ONT	1.50	300.0	10
47	Winnipeg, MAN	1.59	142.0	10

TABLE 2

LATITUDE, LONGITUDE AND ALTITUDE OF THE RAINFALL RECORDING STATIONS

	Location	Lat deg min	Long deg min	Altitude (m)
1	Calgary, ALTA	51 06	114 01	1079
2	Cambridge Bay, NWT	69 06	105 07	23
3	Caplan, QUE	48 06	065 39	37
4	Carmacks, YT	62 06	136 18	
5	Central Patricia, ONT	51 30	090 09	373
6	Churchill, MAN	58 45	094 04	35
7	Comox, BC	49 43	124 54	24
8	Dauphin, MAN	51 06	100 03	305
9	Edmonton, ALTA	53 34	113 31	677
10	Fredericton, NB	45 55	066 37	40
11	Gagnon, QUE	51 57	068 08	572
12	Gander, NFLD	48 57	054 34	147
13	Geraldton, ONT	49 41	086 57	330
14	Goose Bay, NFLD	53 19	060 25	44
15	Halifax, NS	44 38	063 30	41
16	Hope, BC	49 23	121 26	39
17	Kentville, NS	45 04	064 29	31
18	Kingston, ONT	44 14	076 29	104
19	London, ONT	43 02	081 09	278
20	Mission, BC	49 09	122 16	56
21	Montreal, QUE	45 28	073 45	30
22	Moosonee, ONT	51 16	080 39	10
23	Normandin,QUE	48 51	072 32	137
24	North Bay, ONT	46 22	079 25	369
25	Ottawa, ONT	45 23	075 43	126
26	Poste de la Baleine, QUE	55 17	077 46	26
27	Prince Albert, SASK	53 13	105 41	431
28	Prince George, BC	53 53	122 40	676
29	Quebec, QUE	46 48	071 23	75
30	Regina, SASK	50 26	104 40	573
31	Saint John, NB	45 19	065 53	107
32	St. John's, NFLD	47 37	052 45	141
33	Sault Ste. Marie, ONT	46 29	084 30	347
34	Sioux Lookout, ONT	50 07	091 54	374
35	Stephenville, NFLD	48 32	058 33	13
36	Summerland, BC	49 34	119 39	454
37	Summerside, PEI	46 26	063 50	24
38	Swift Current, SASK	50 16	107 44	816
39	Sydney, NS	46 10	060 03	60
40	Toronto, ONT	43 41	079 38	176
41	Uranium City, SASK	59 34	108 29	312
42	Val d'Or, QUE	48 03	077 47	338
43	Vancouver, BC	49 11	123 10	3
44	Watino, ALTA	55 43	117 37	
45	Weyburn,SASK	49 40	103 51	567
46	Windsor, ONT	42 16	082 58	194
47	Winnipeg, MAN	49 54	097 14	240

Figs. 11-19 (pages 36-44)

Rain attenuation exceedance contours for a major part of Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for the following values of P.

The legend gives the attenuation exceedance values for the contours. The longitude of the satellite is 100° W and there is no site diversity. The latitude and longitude of the boundaries are indicated. The min. and max. attenuation exceedance values over the region are also shown.

Frequency	**Percentage P of time of an average year when the rain attenuation exceeds the value corresponding to a contour.**
20 GHz	(1) P = 0.5% ; (2) P = 0.1% ; (3) P = 0.01% .
30 GHz	(1) P = 1.0% ; (2) P = 0.5% ; (3) P = 0.1% .
44 GHz	(1) P = 1.0% ; (2) P = 0.5% ; (3) P = 0.1% .

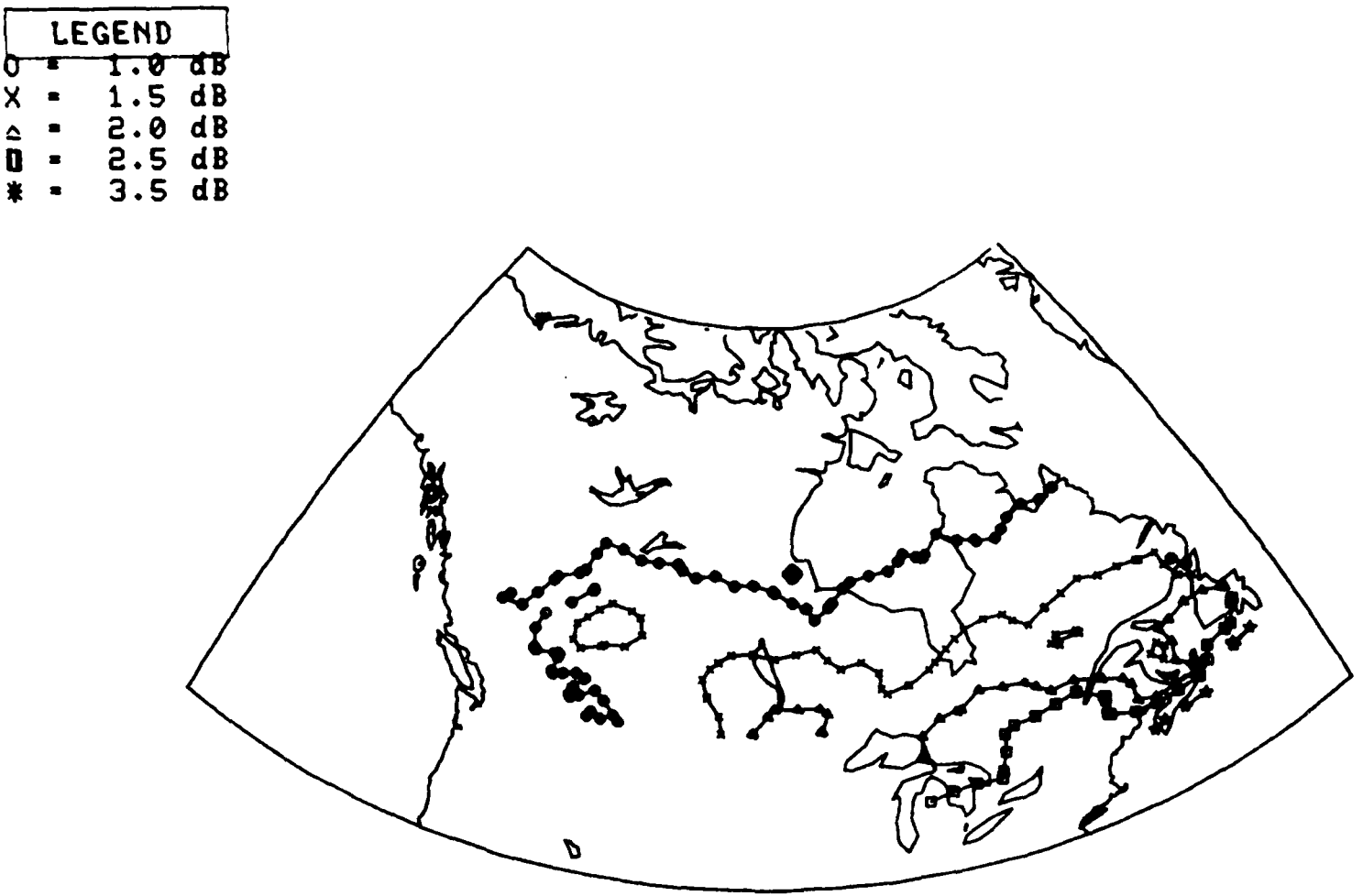
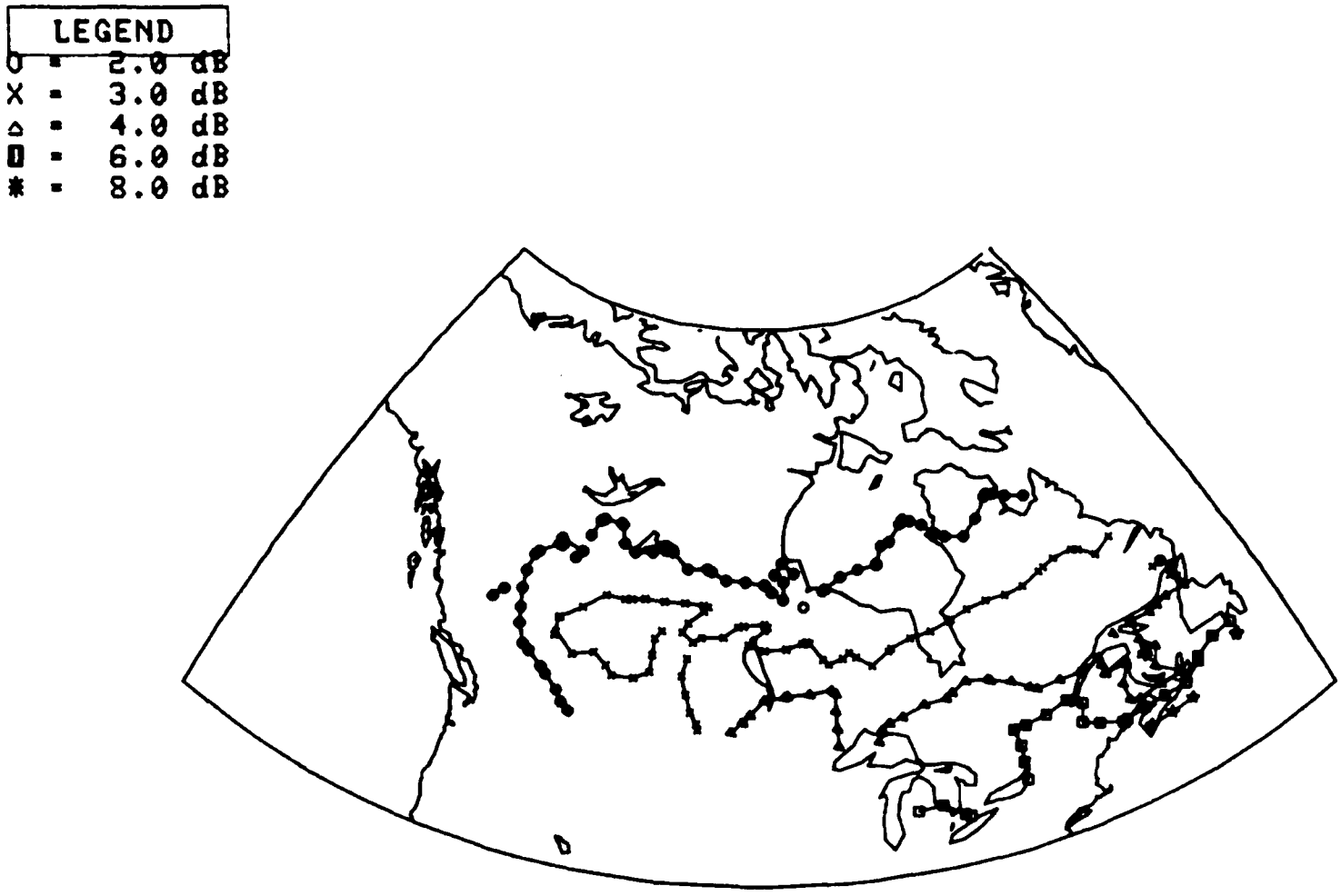

LEGEND
o = 1.0 dB
X = 1.5 dB
△ = 2.0 dB
□ = 2.5 dB
* = 3.5 dB
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 0.23, 3.87 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 11



CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 0.51, 8.51 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 12

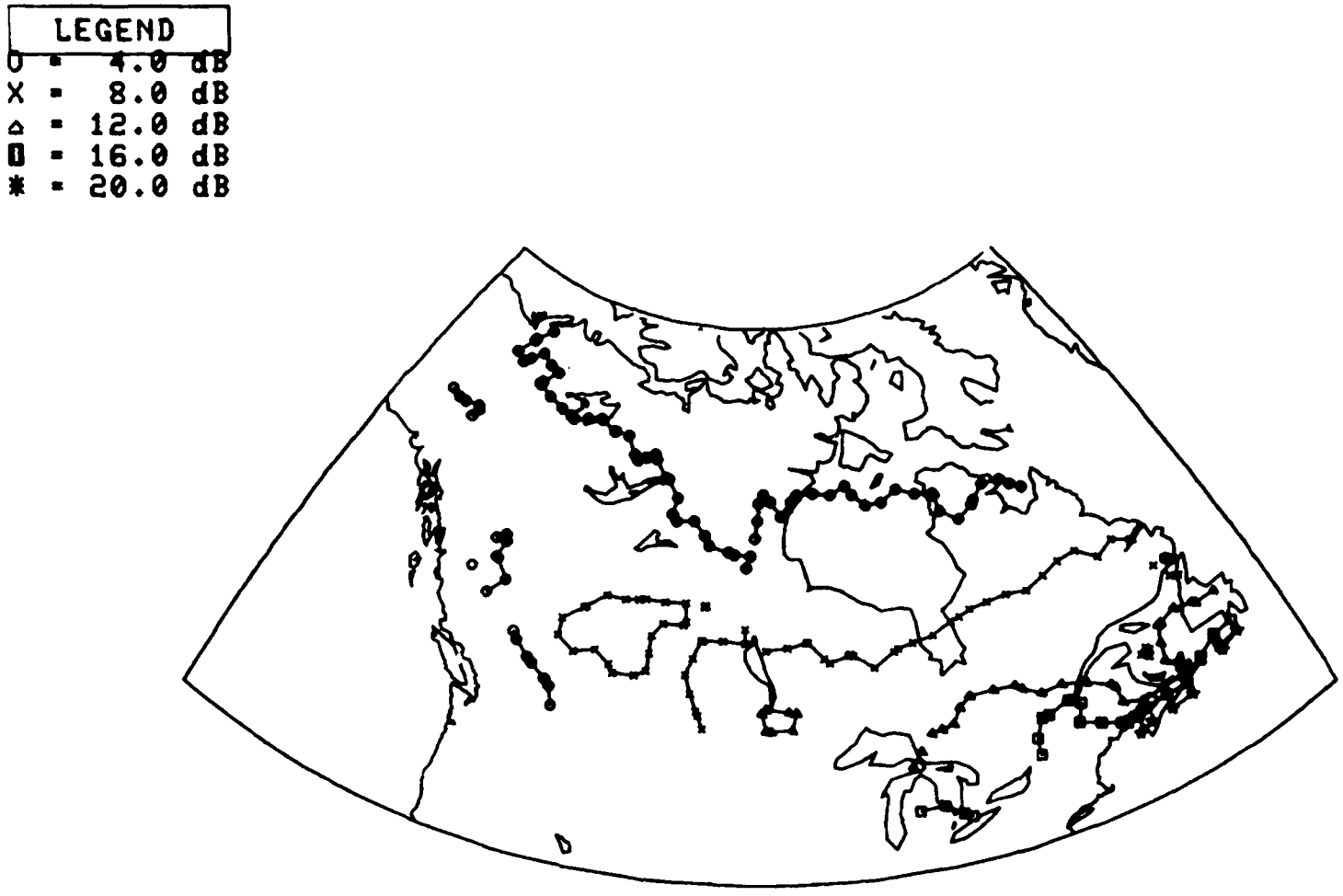
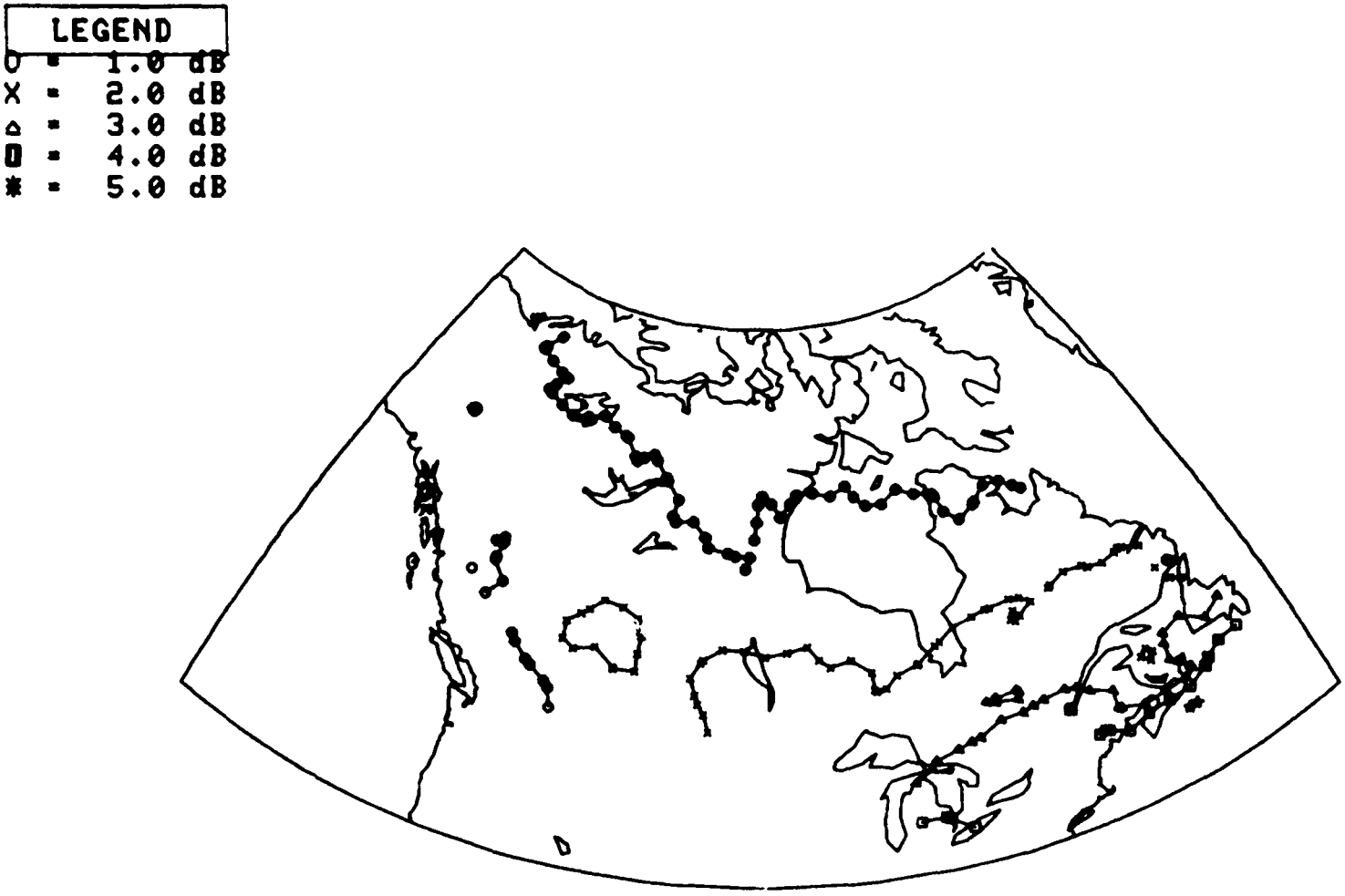

LEGEND
0 = 4.0 dB
X = 8.0 dB
△ = 12.0 dB
□ = 16.0 dB
* = 20.0 dB
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.010% OF YR MIN,MAX: 1.32,22.22 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 13

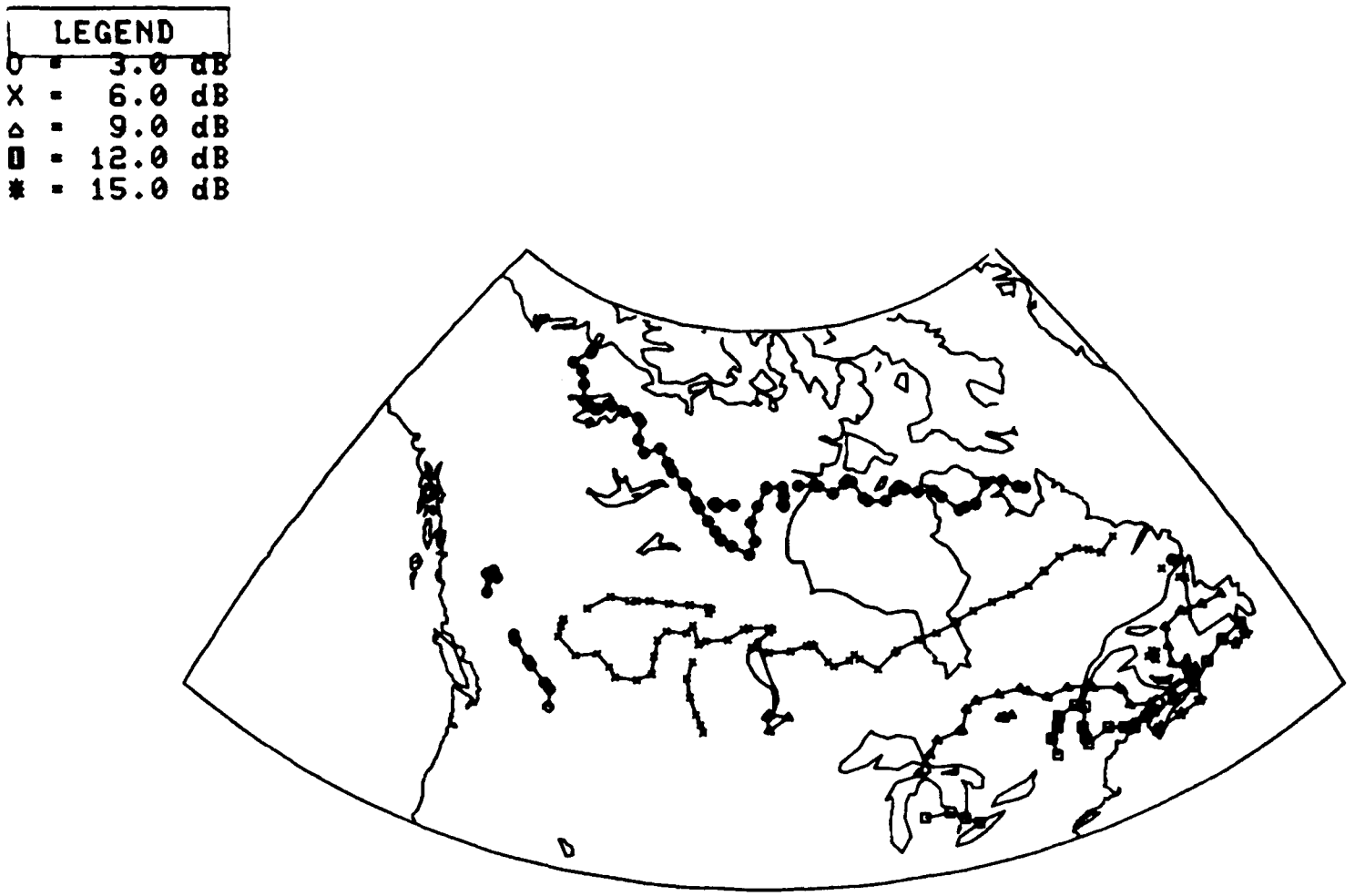


CANSLAM; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
EXCEEDANCE FOR 1.000% OF YR MIN,MAX: 0.36, 5.05 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 14

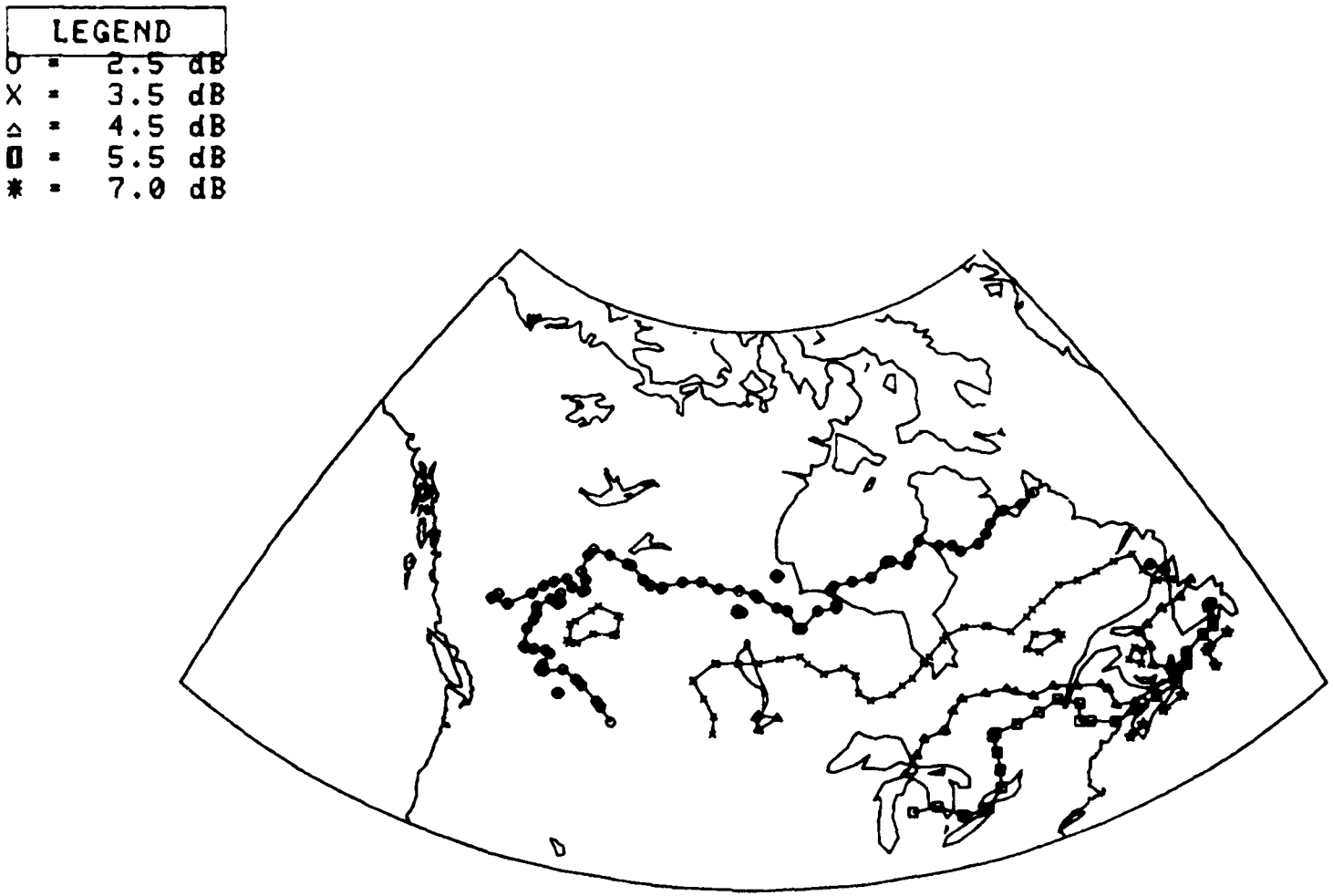
LEGEND
o = 1.0 dB
X = 2.5 dB
Δ = 4.0 dB
□ = 5.5 dB
* = 7.0 dB
CANSLAM; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 0.52, 7.30 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 15



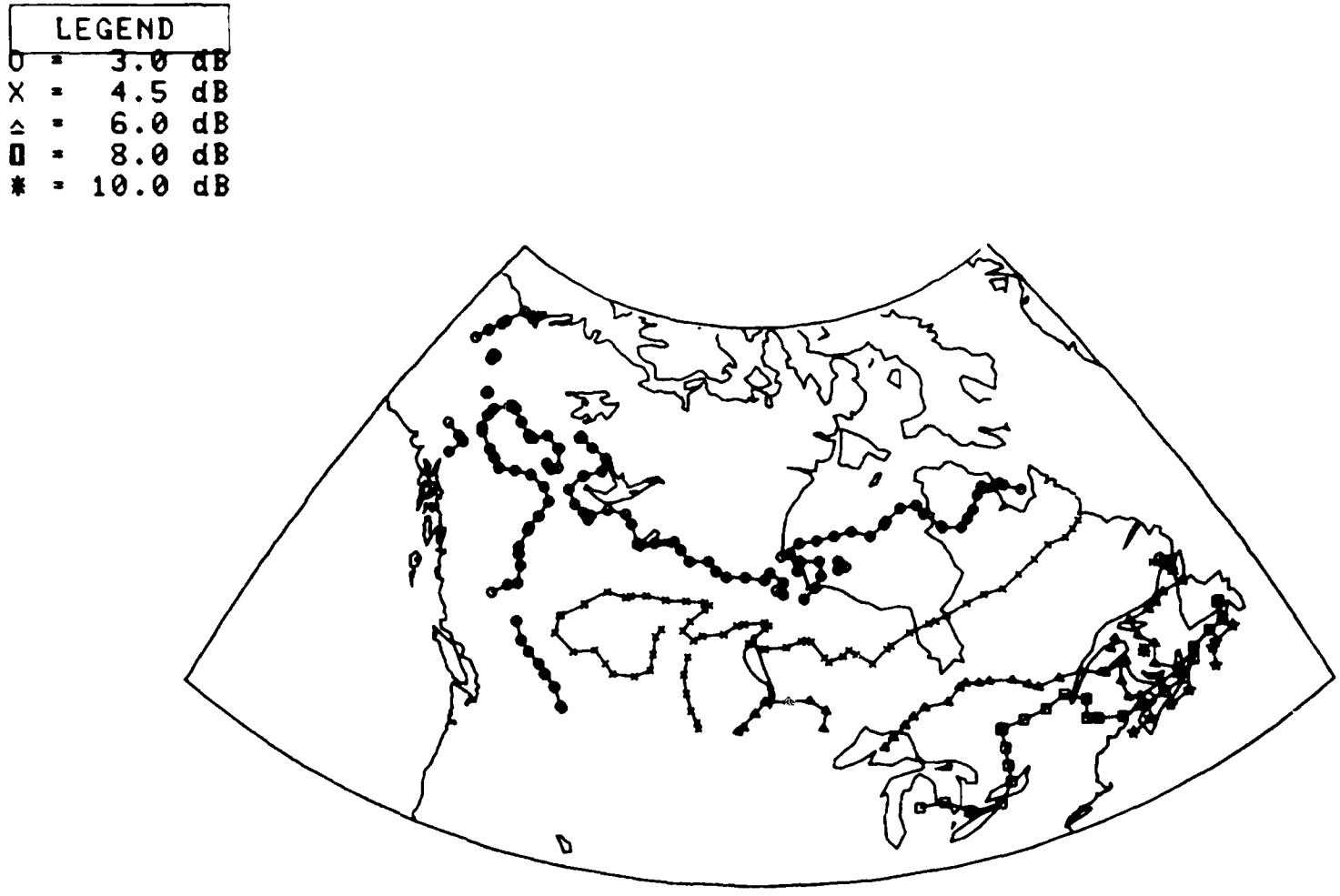
CANSLAM; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 1.14,16.07 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 16



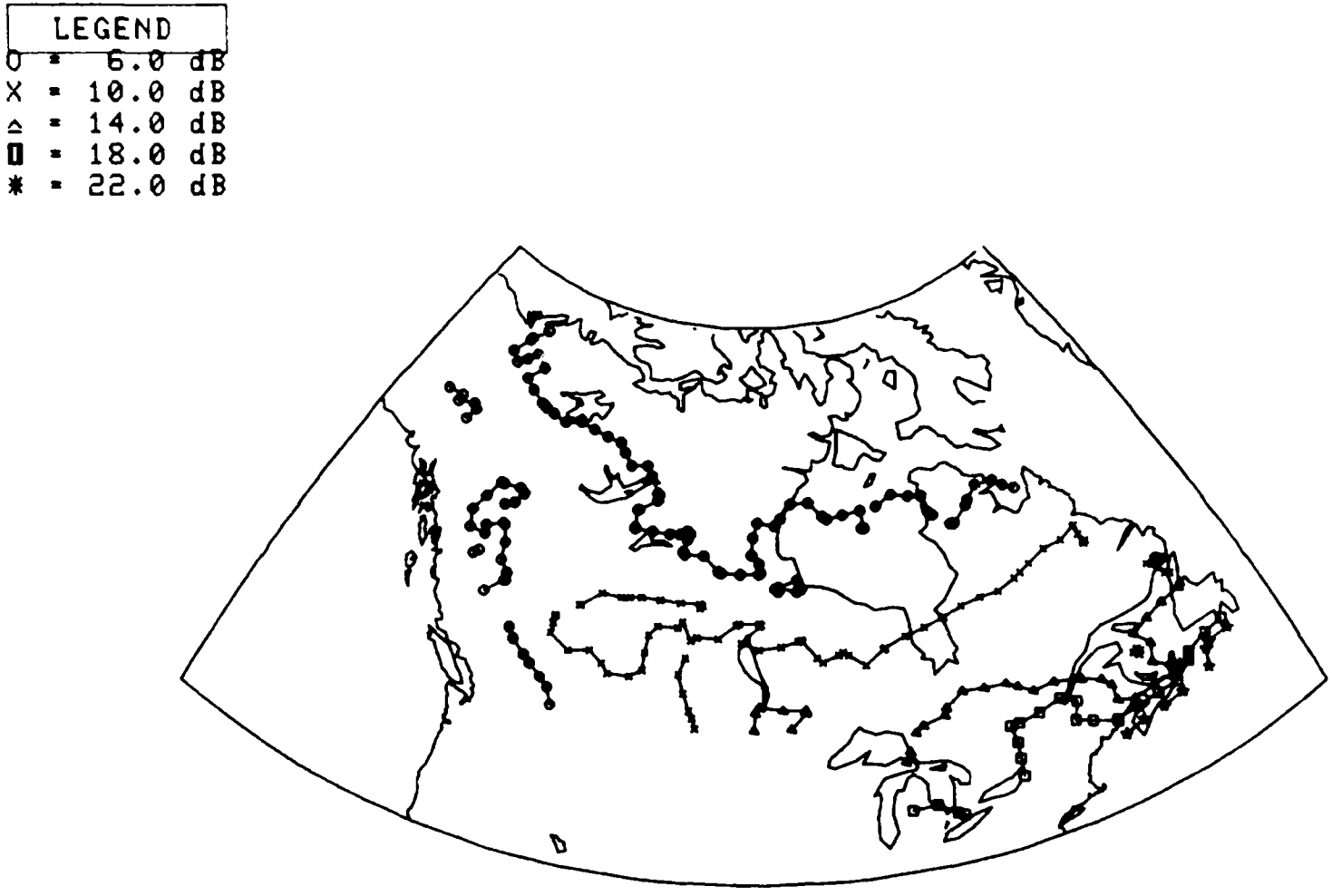
CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 1.000% OF YR MIN,MAX: 0.72, 7.76 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 17



CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 1.04,11.23 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 18



CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 2.28,24.72 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 19

Figs. 20-39 (pages 46-65)	**Rain attenuation exceedance contours for four selected regions in Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for the following values of P.**
	The legend gives the attenuation exceedance values for the contours. The longitude of the satellite is 100° W and there is no site diversity. The latitude and longitude of the boundaries are indicated. The min. and max. attenuation exceedance values over the region are also shown.
Frequency	**Percentage P of time of an average year when the rain attenuation exceeds the value corresponding to a contour.**
20 GHz	(1) P = 0.5% ; (2) P = 0.1% .
30 GHz	(1) P = 0.1% ;
44 GHz	(1) P = 0.5% ; (2) P = 0.1% .

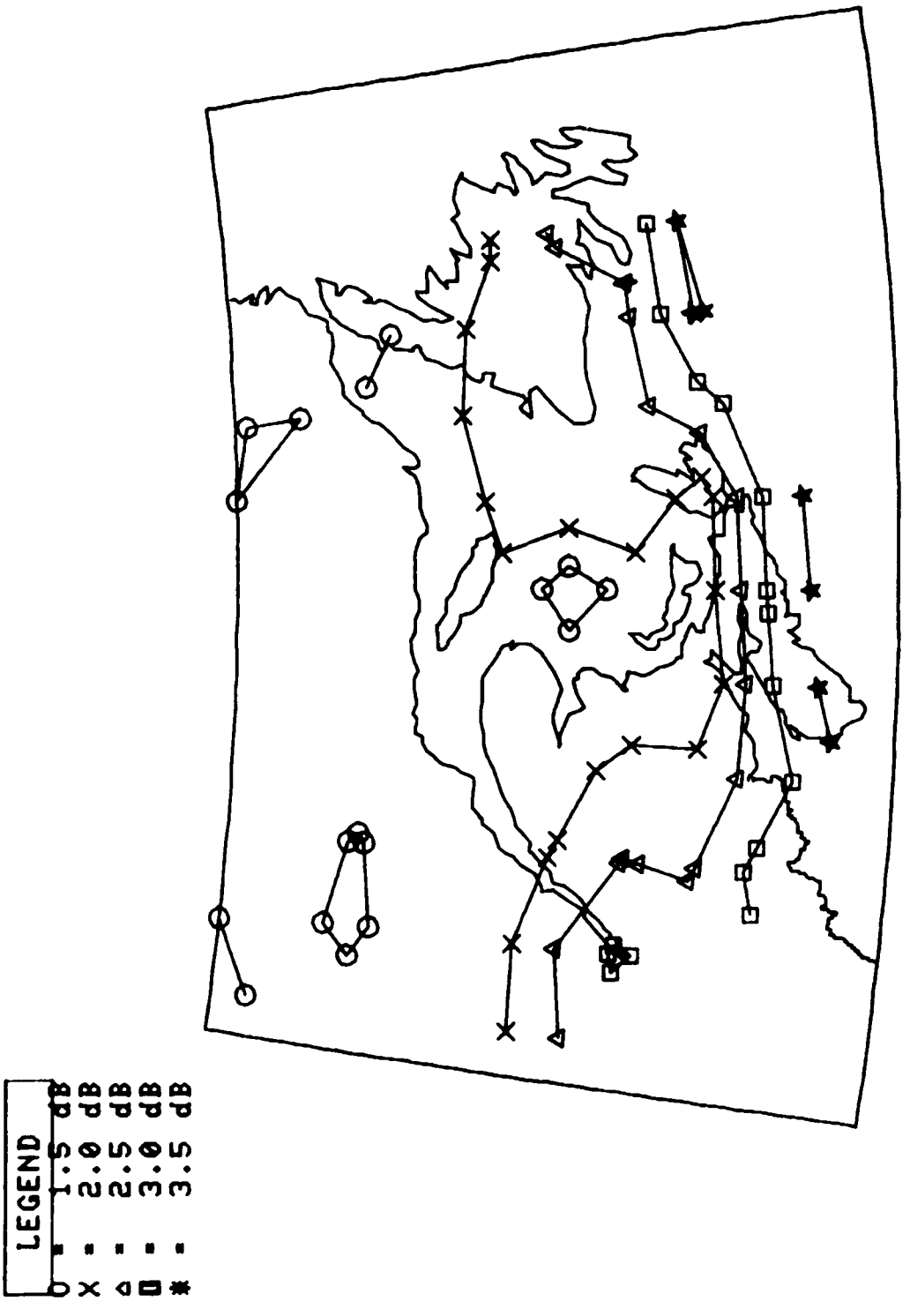
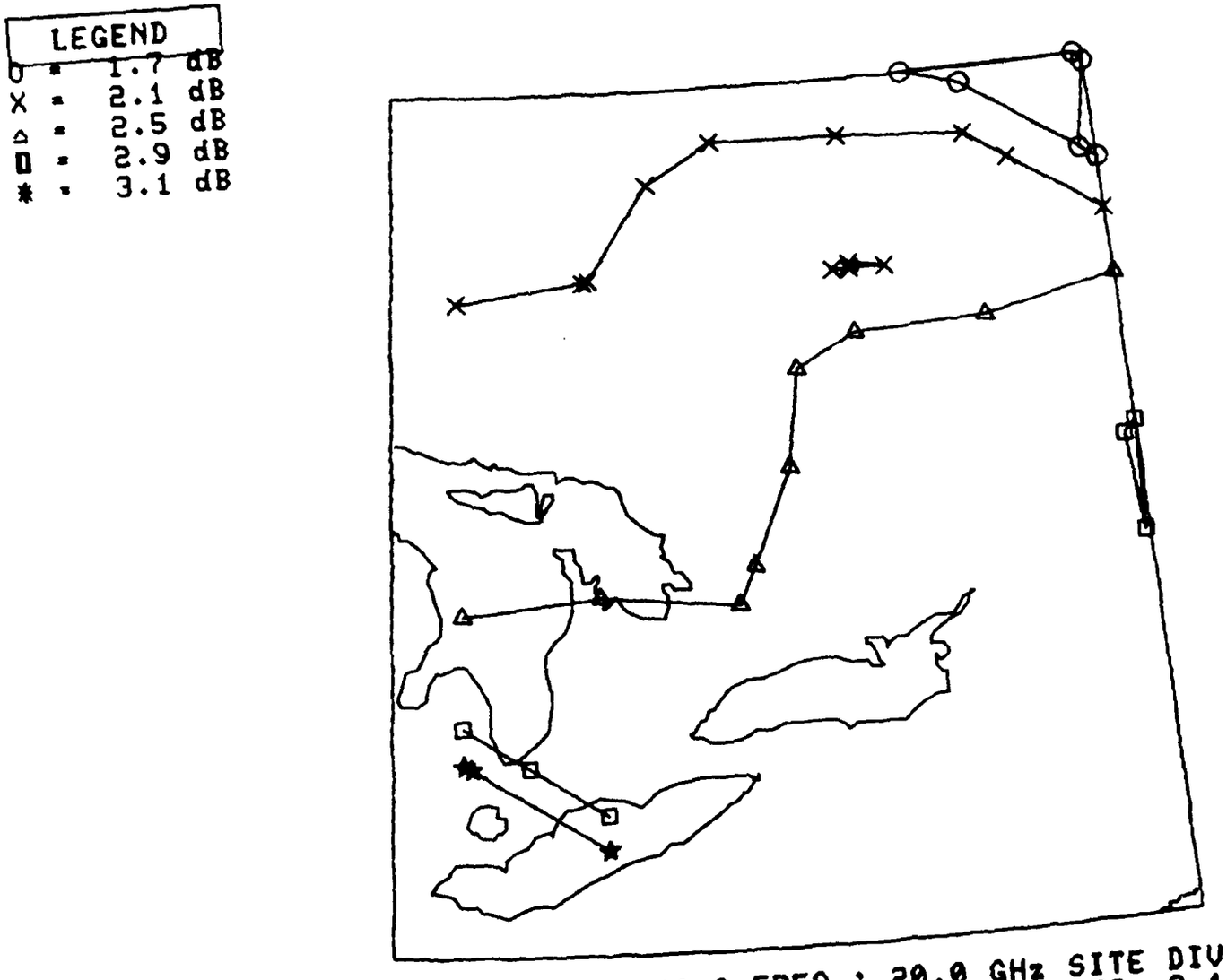

LEGEND
1.5 dB
2.0 dB
2.5 dB
3.0 dB
3.5 dB
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 0.51, 3.87 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 20



CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 1.59, 3.16 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 21

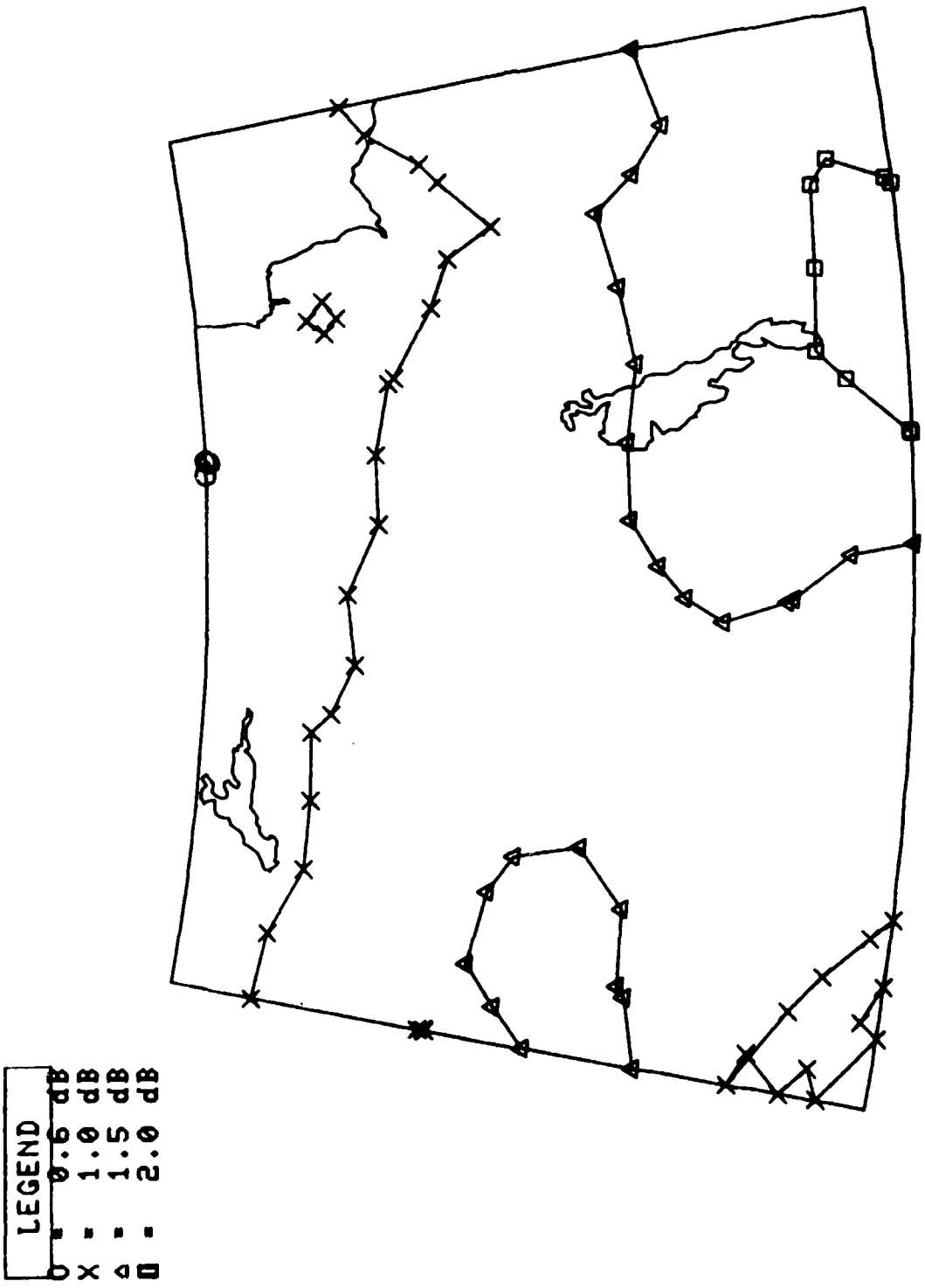
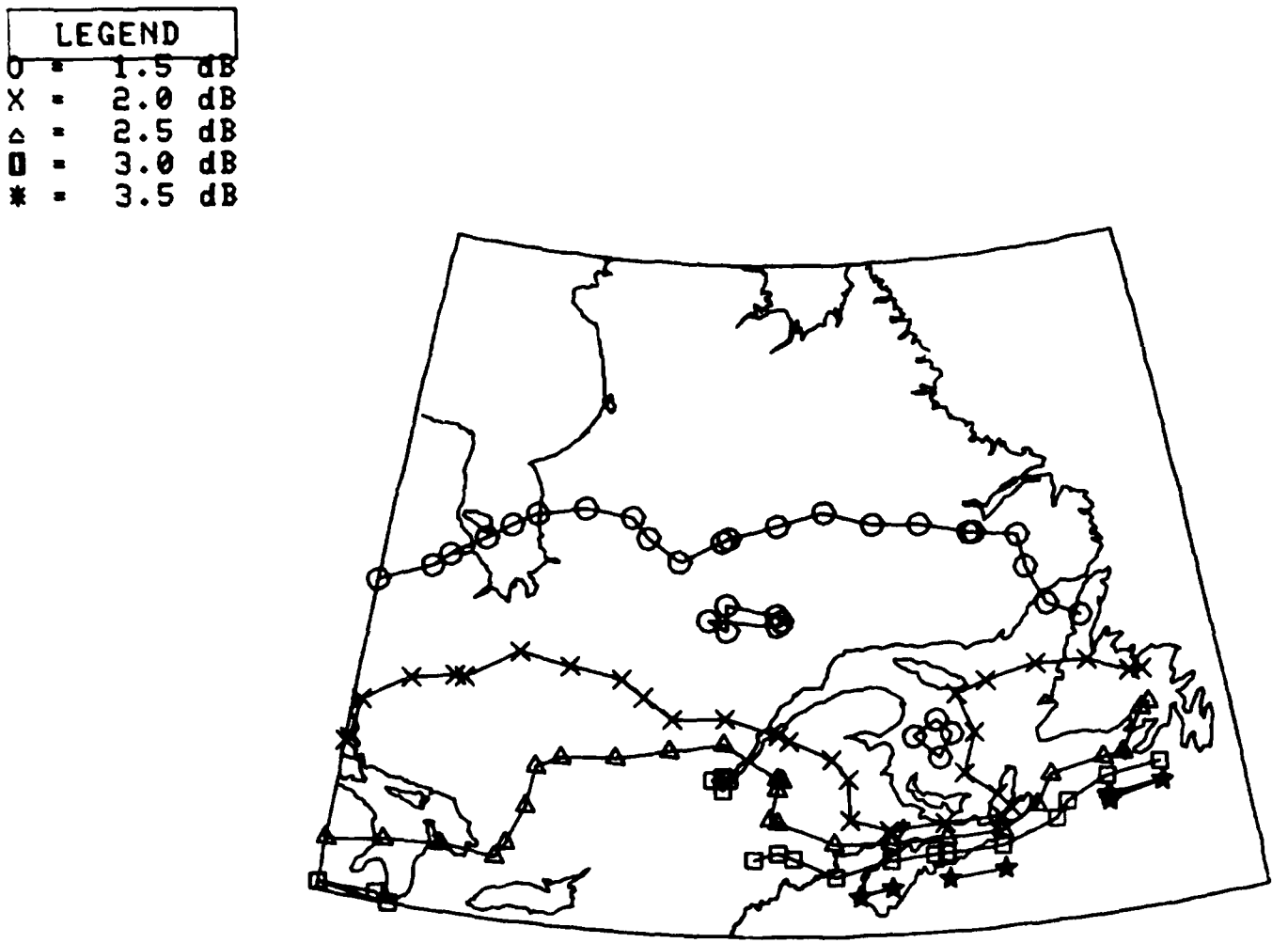
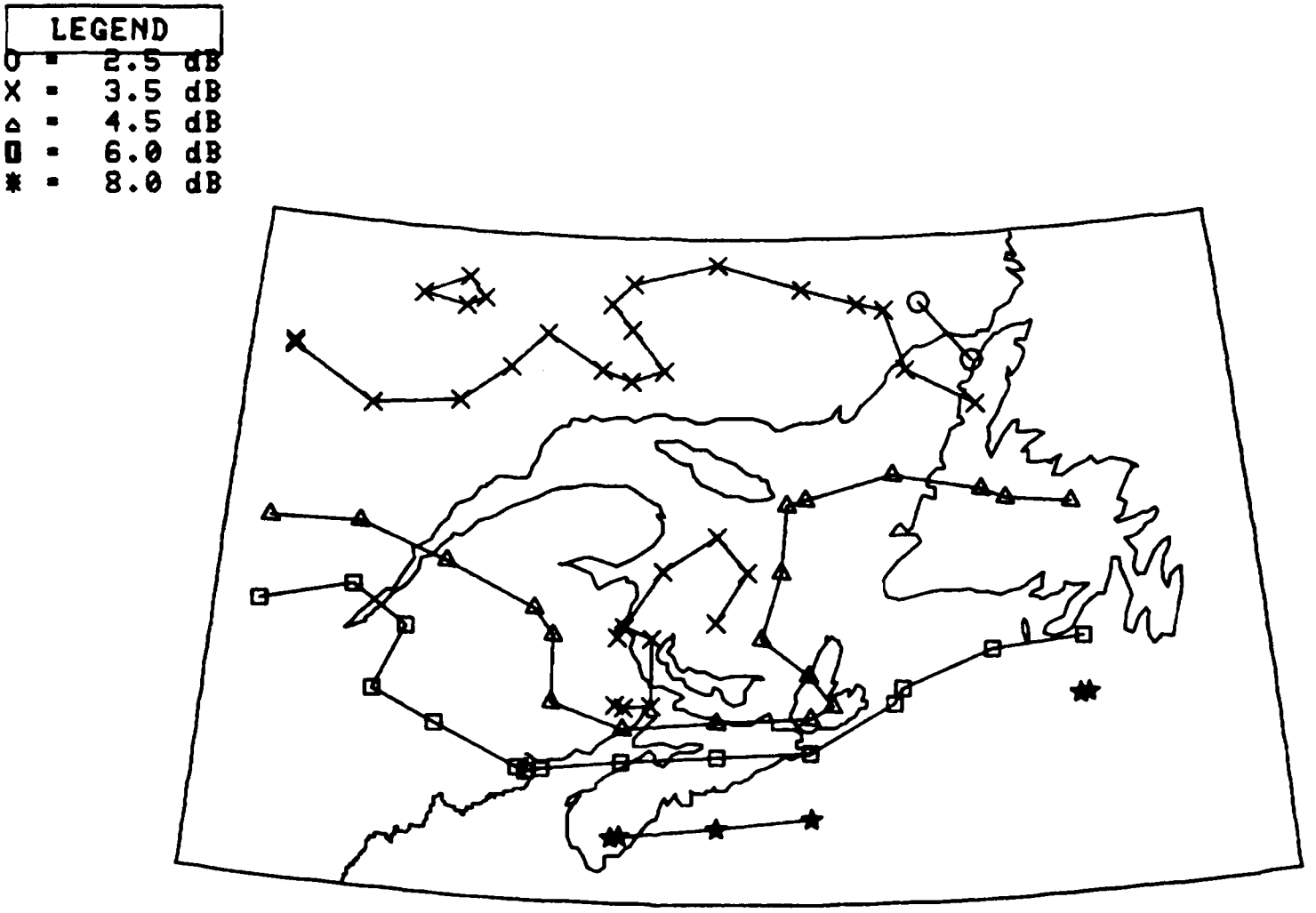

LEGEND
0 = 0.6 dB
X = 1.0 dB
◁ = 1.5 dB
□ = 2.0 dB
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 0.59, 2.20 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 22



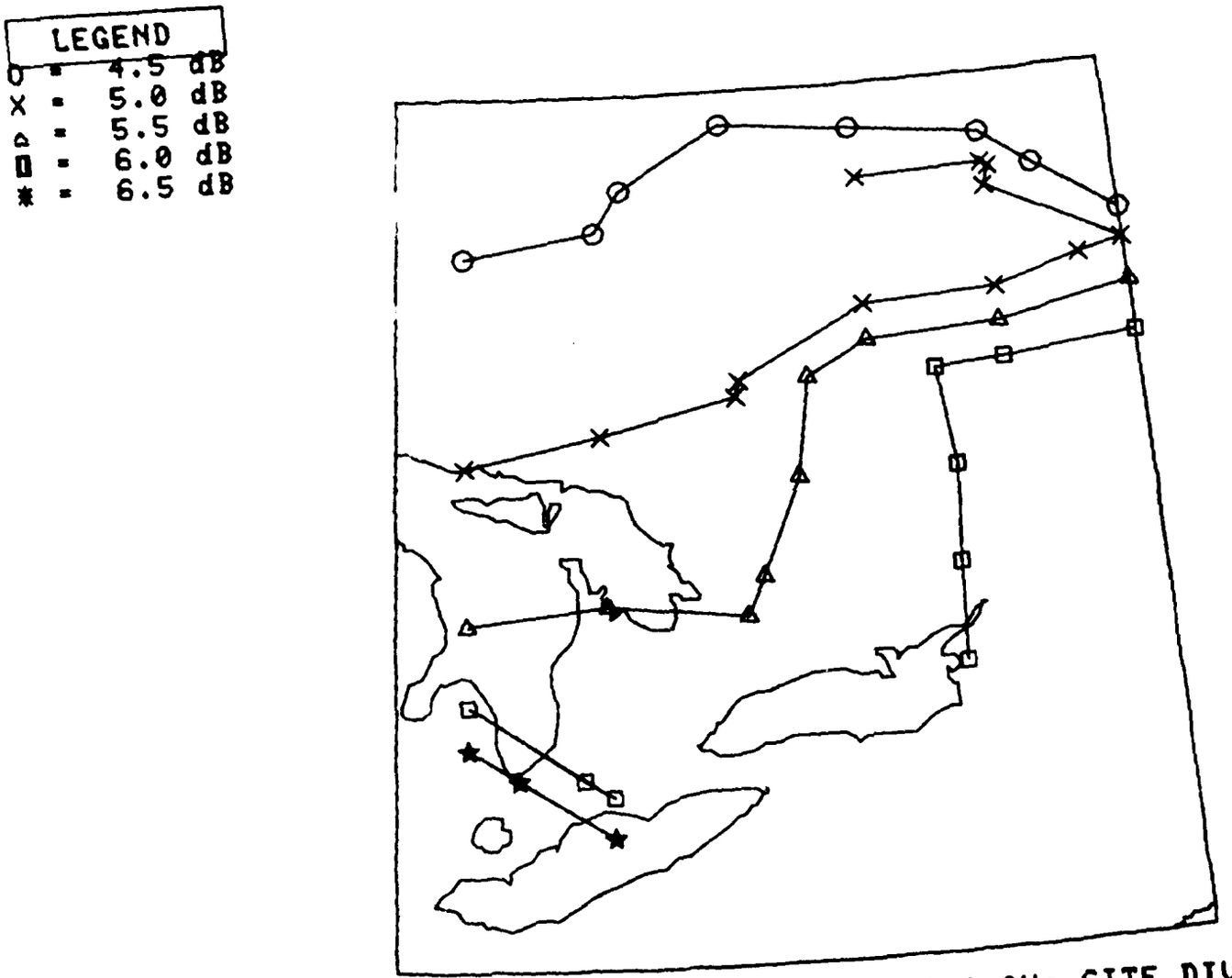
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 0.51, 3.87 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 23



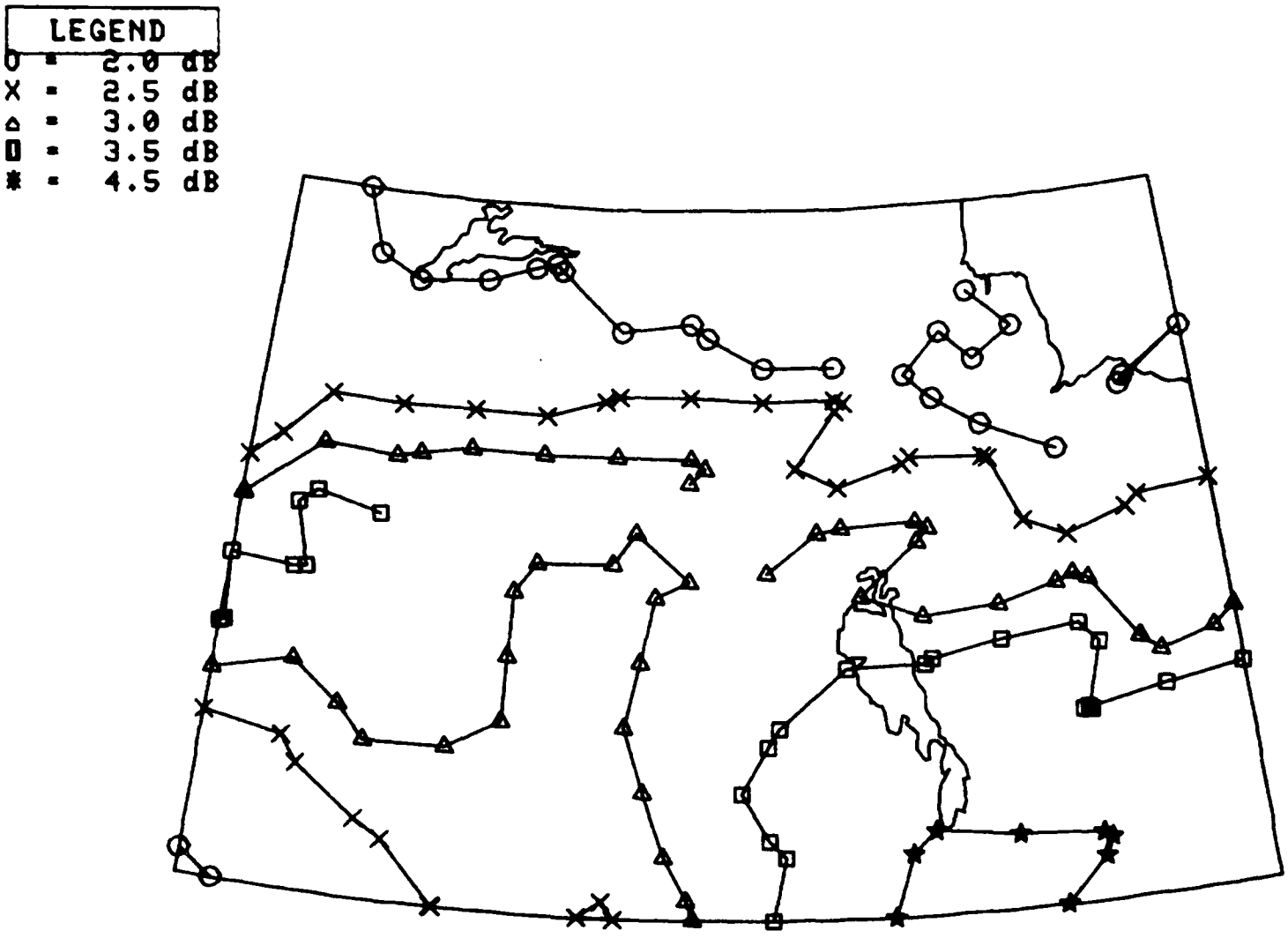
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 1.12, 8.51 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 24



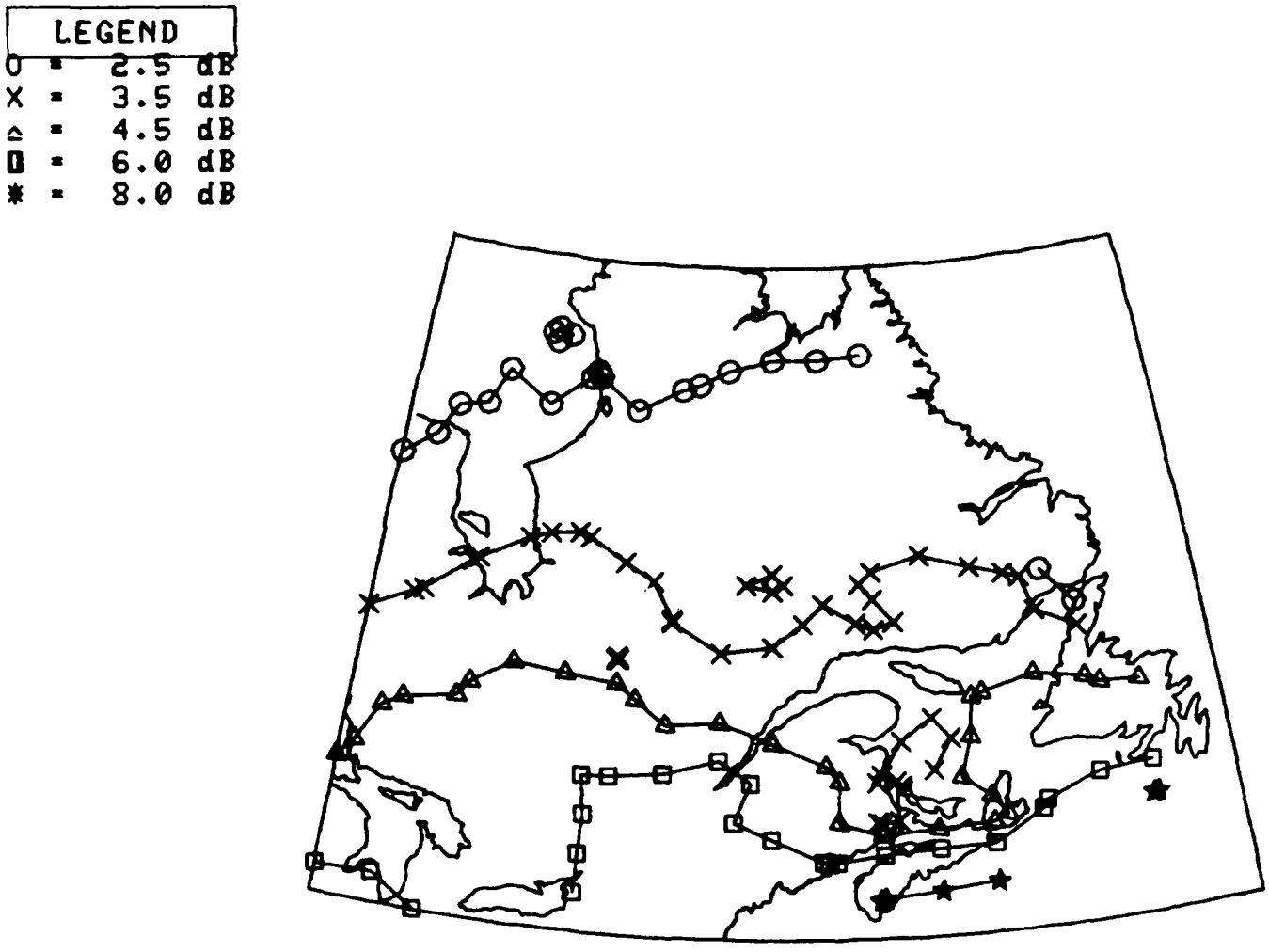
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 3.49, 6.96 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 25



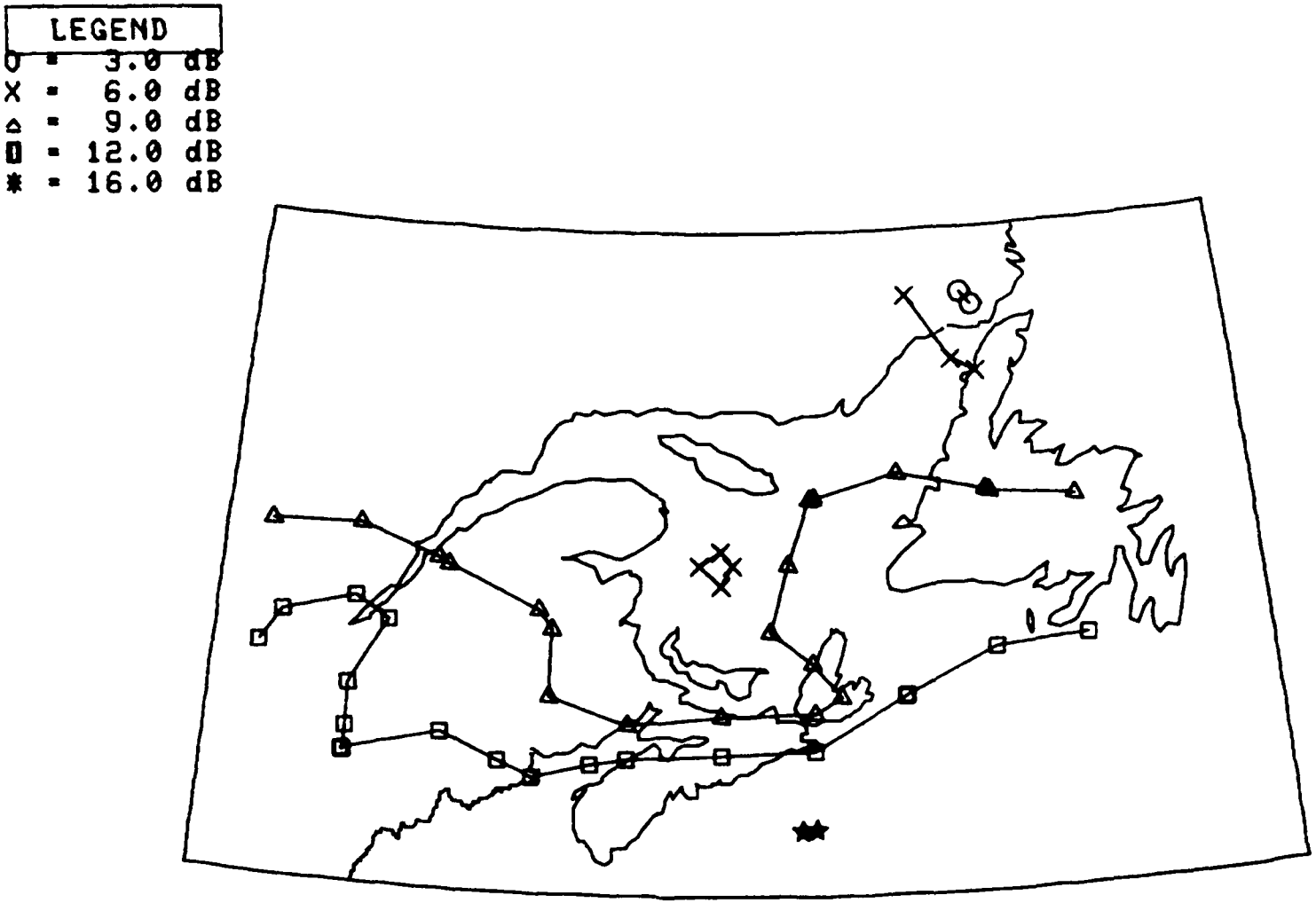
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 1.31, 4.84 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 26



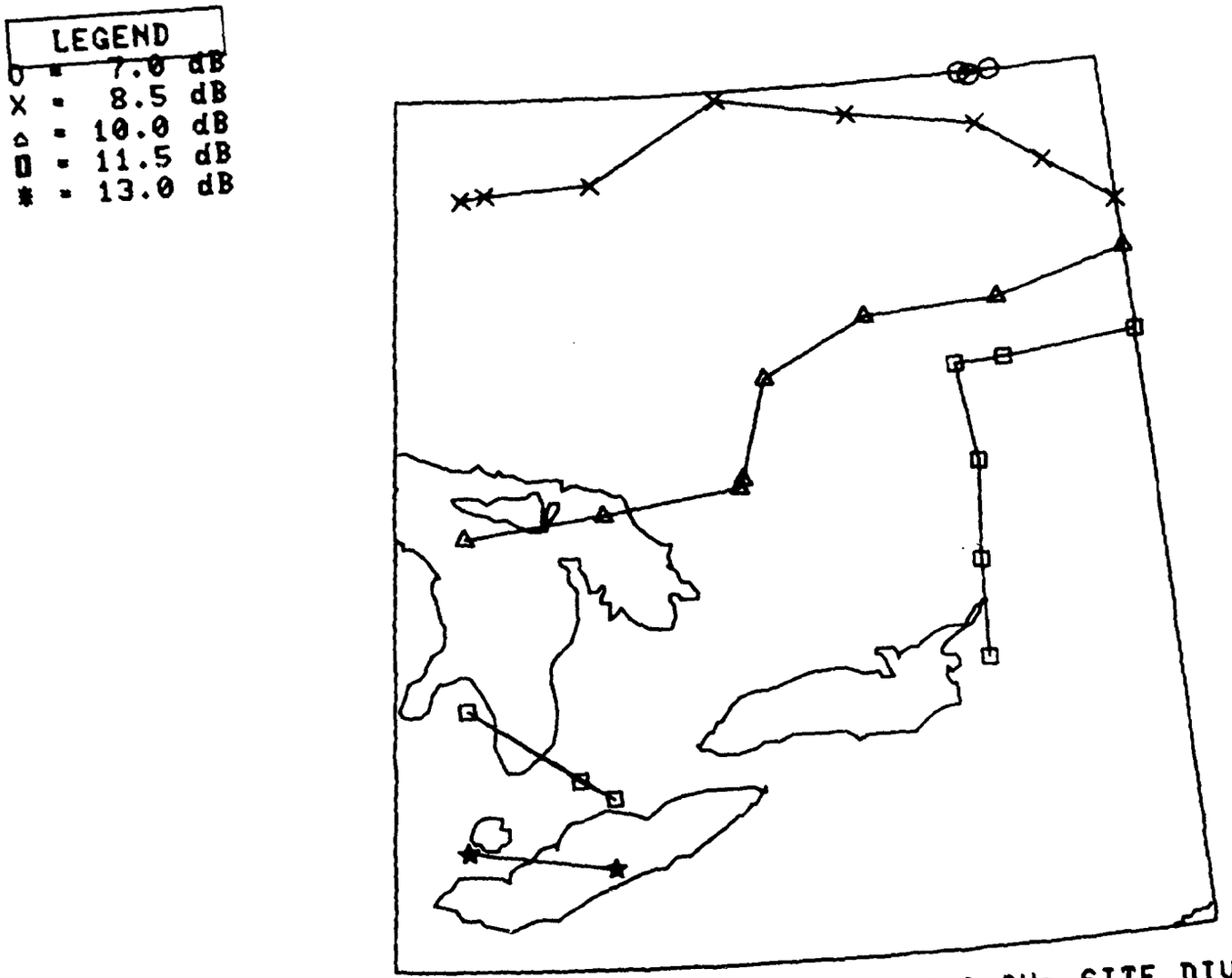
CANSLAM; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 1.12, 8.51 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 27



CANSLAM; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 2.43,16.07 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 28



CANSLAM; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 6.92,13.16 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 29

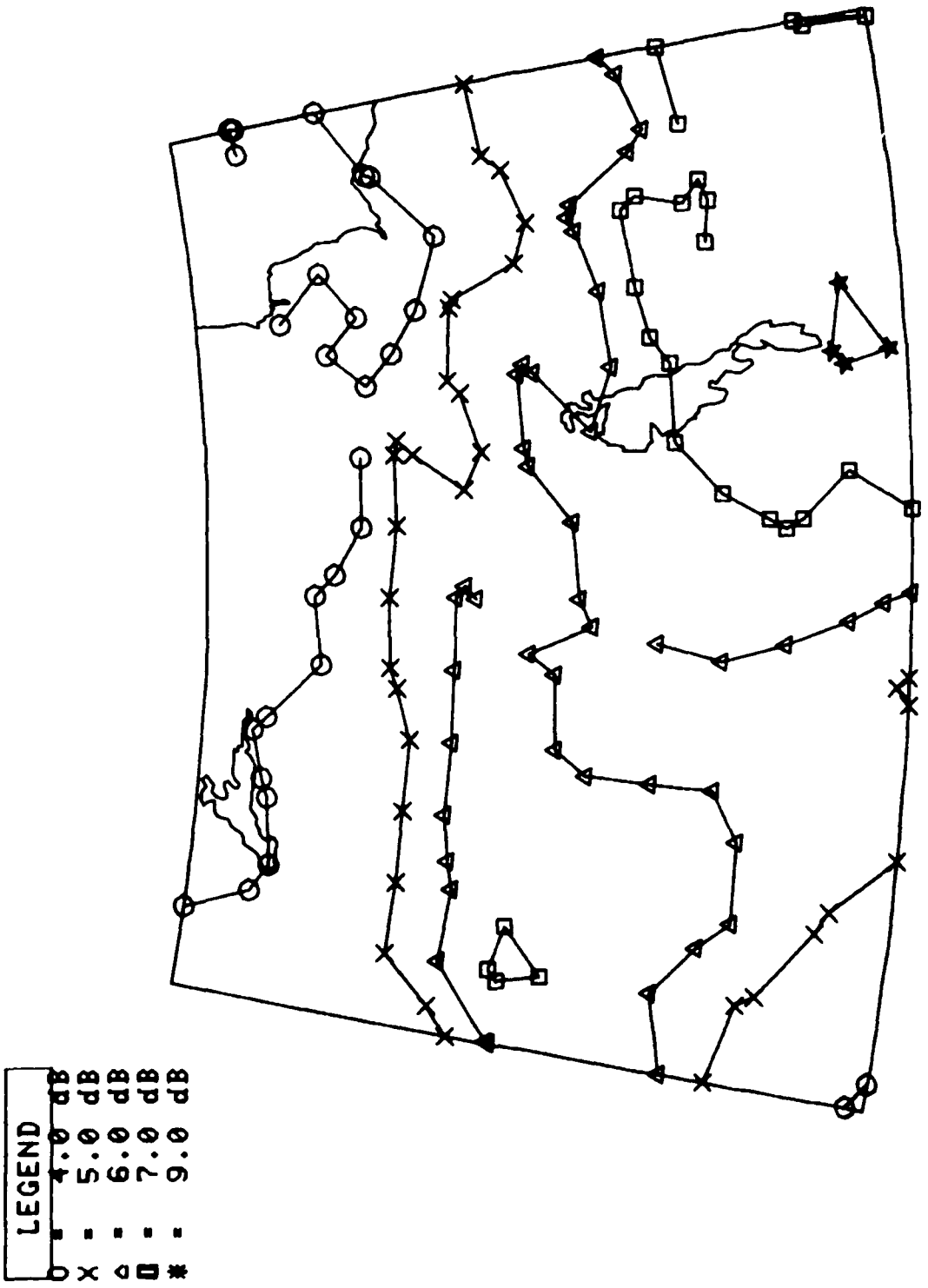
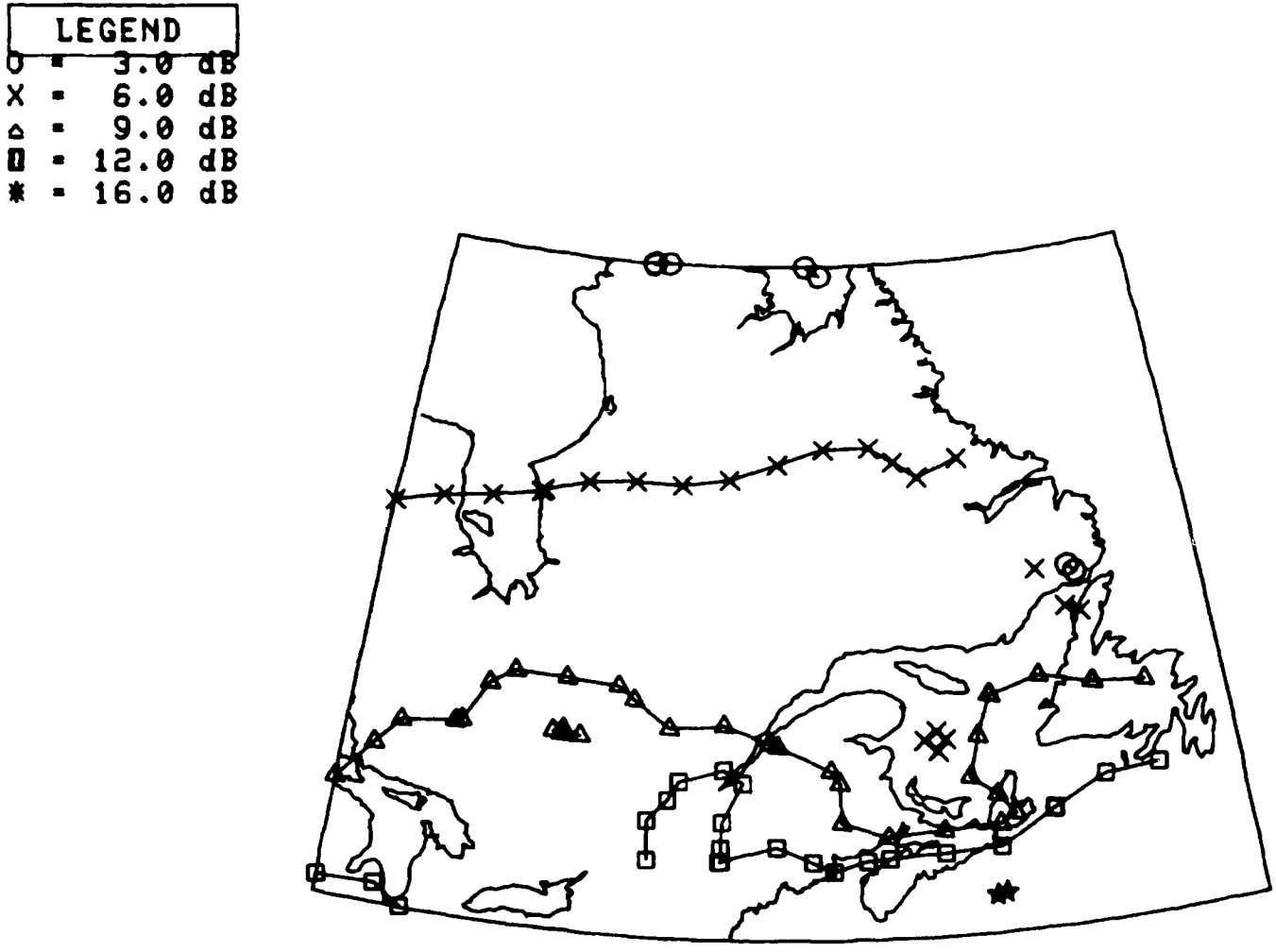
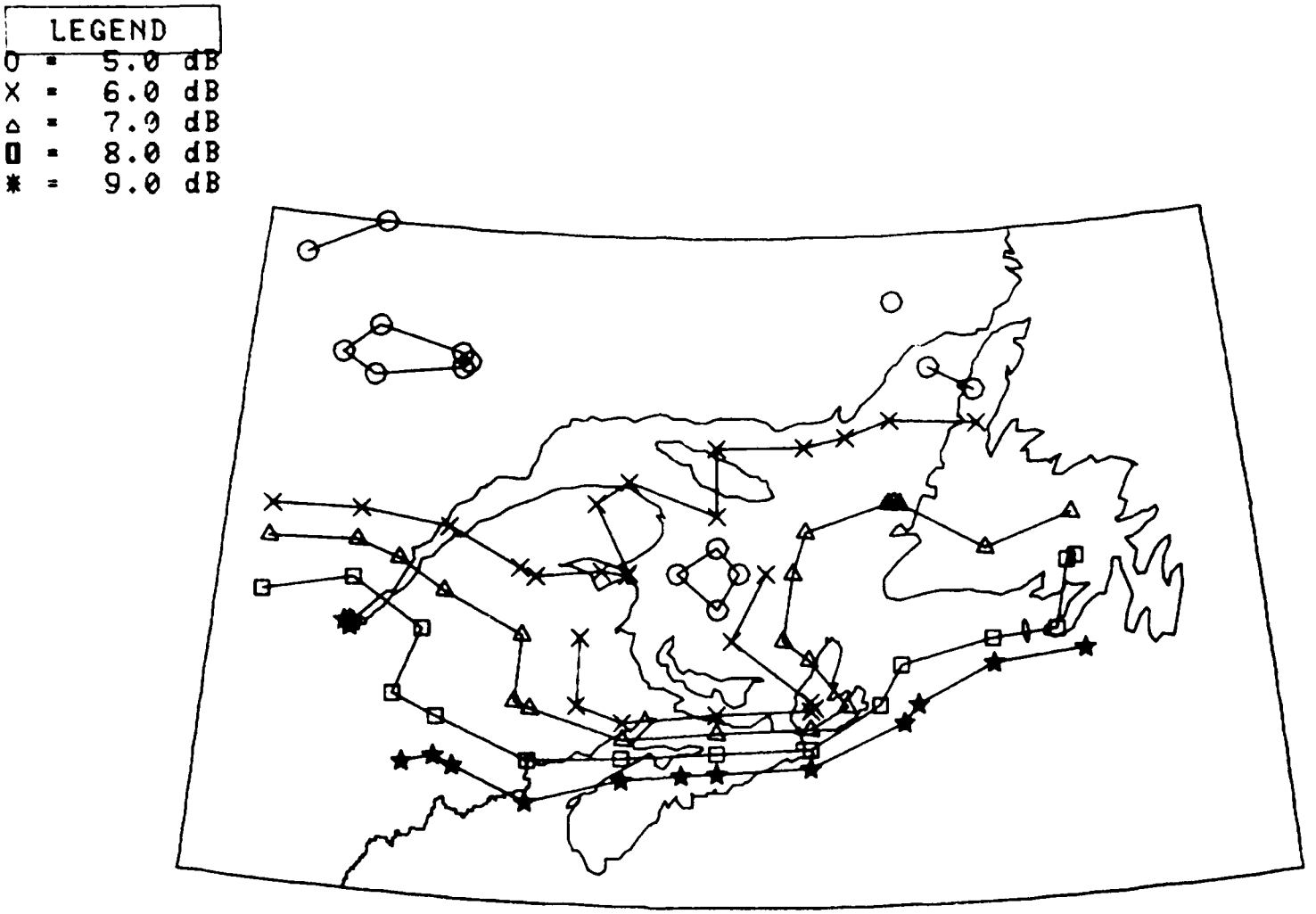

LEGEND
4.0 dB
5.0 dB
6.0 dB
7.0 dB
9.0 dB
CANSLAM; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 2.76, 9.33 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 30



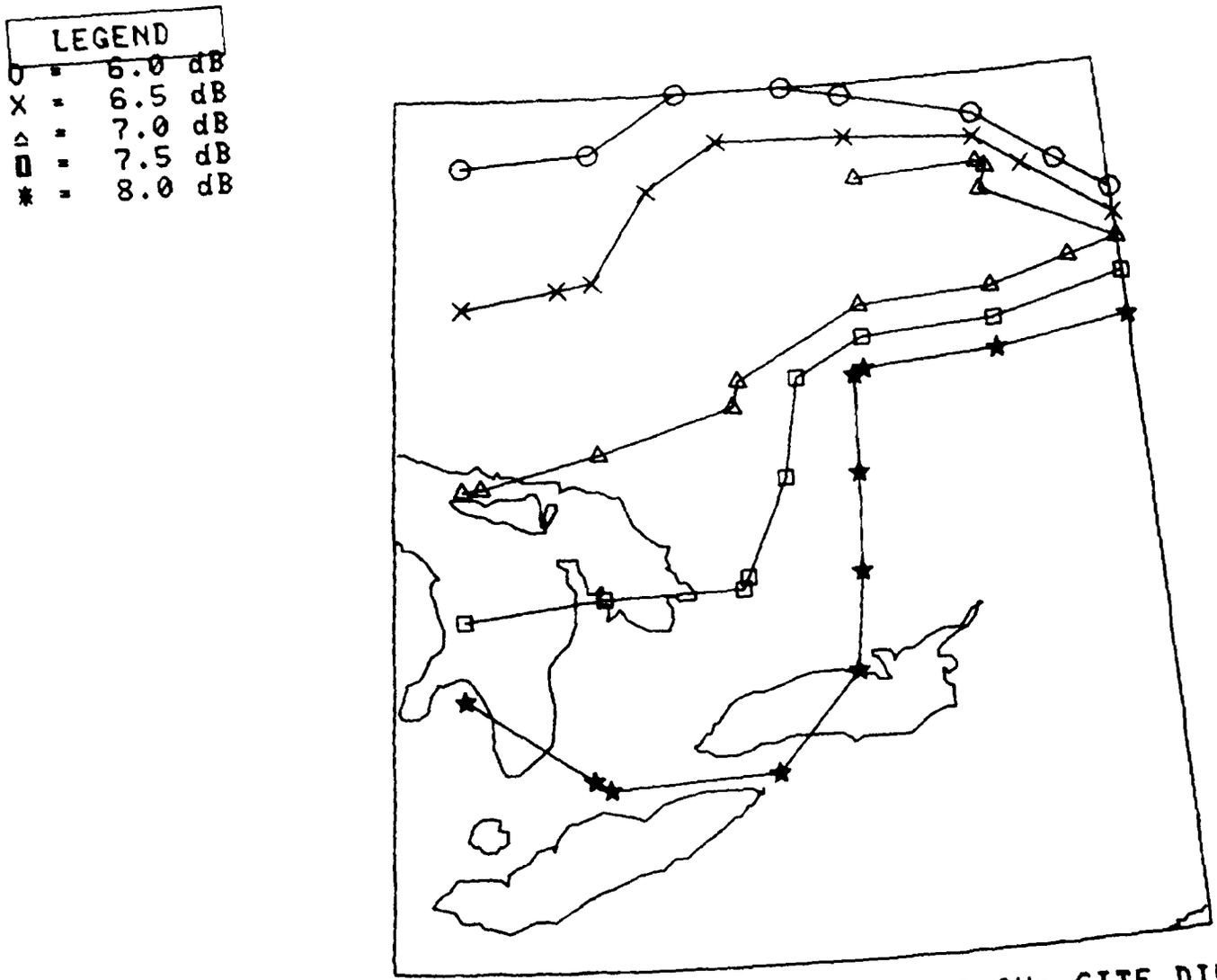
CANSLAM; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 2.43,16.07 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 31



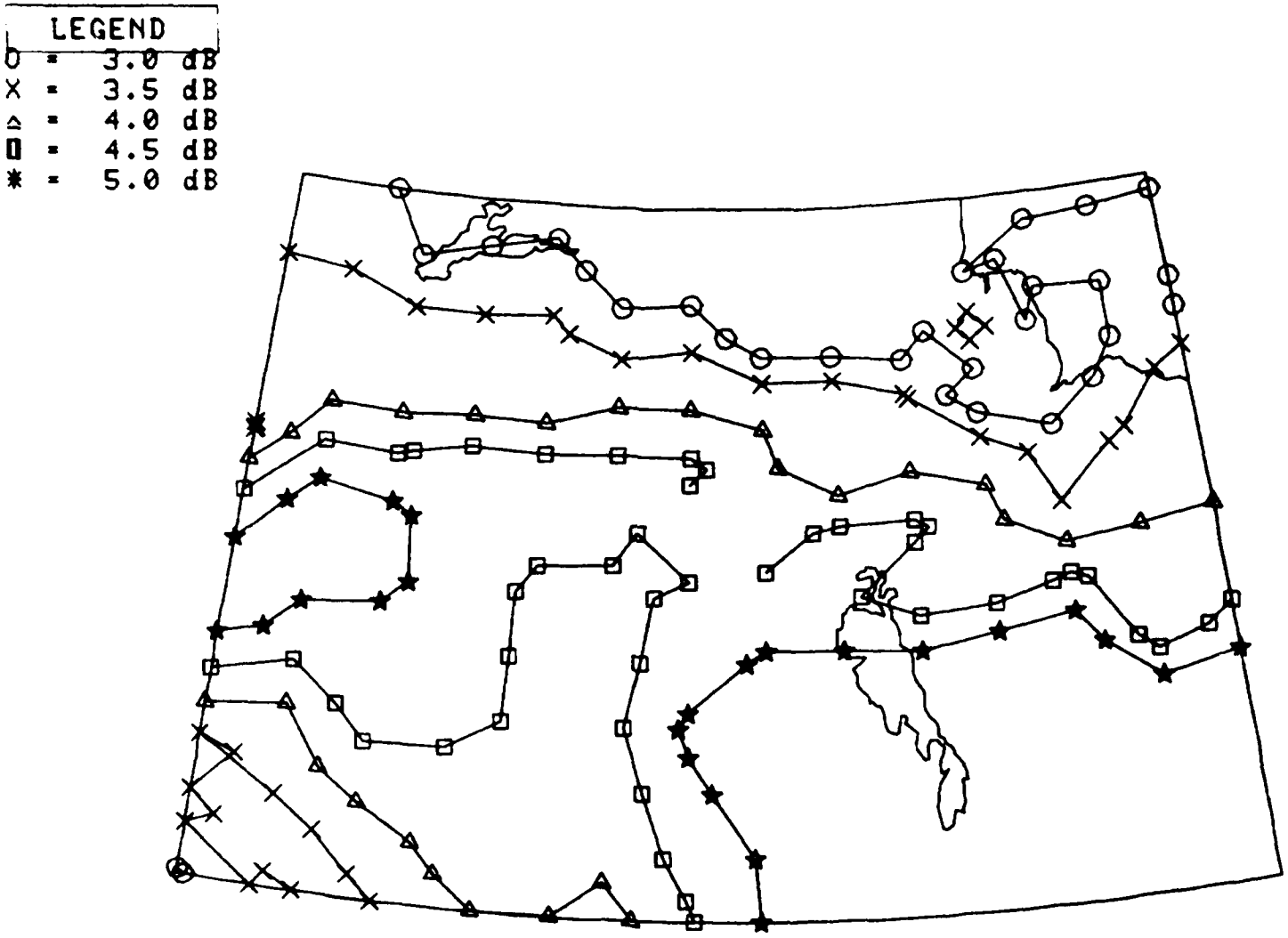
CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 2.08,11.23 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 32



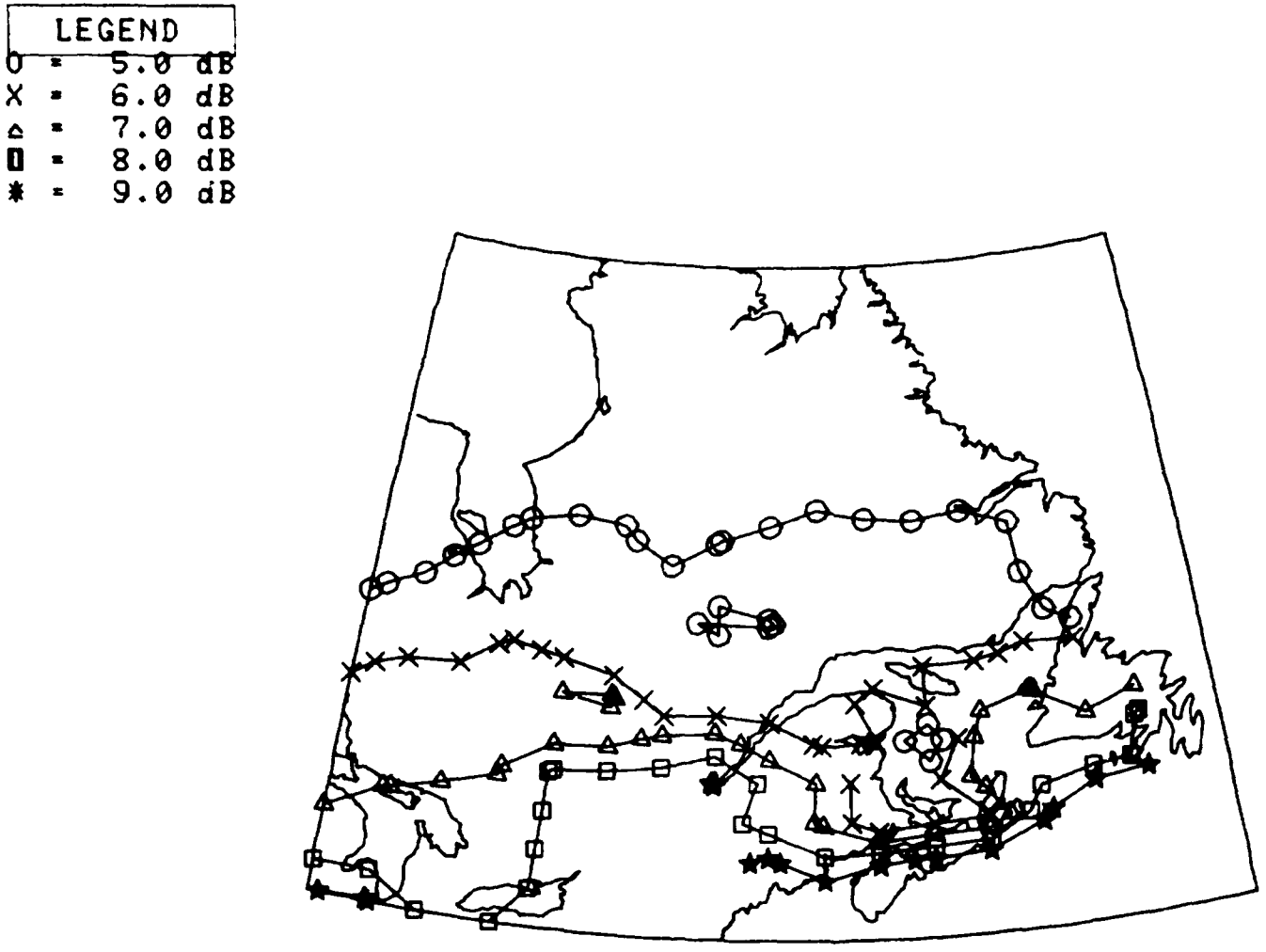
CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 5.19, 9.19 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 33



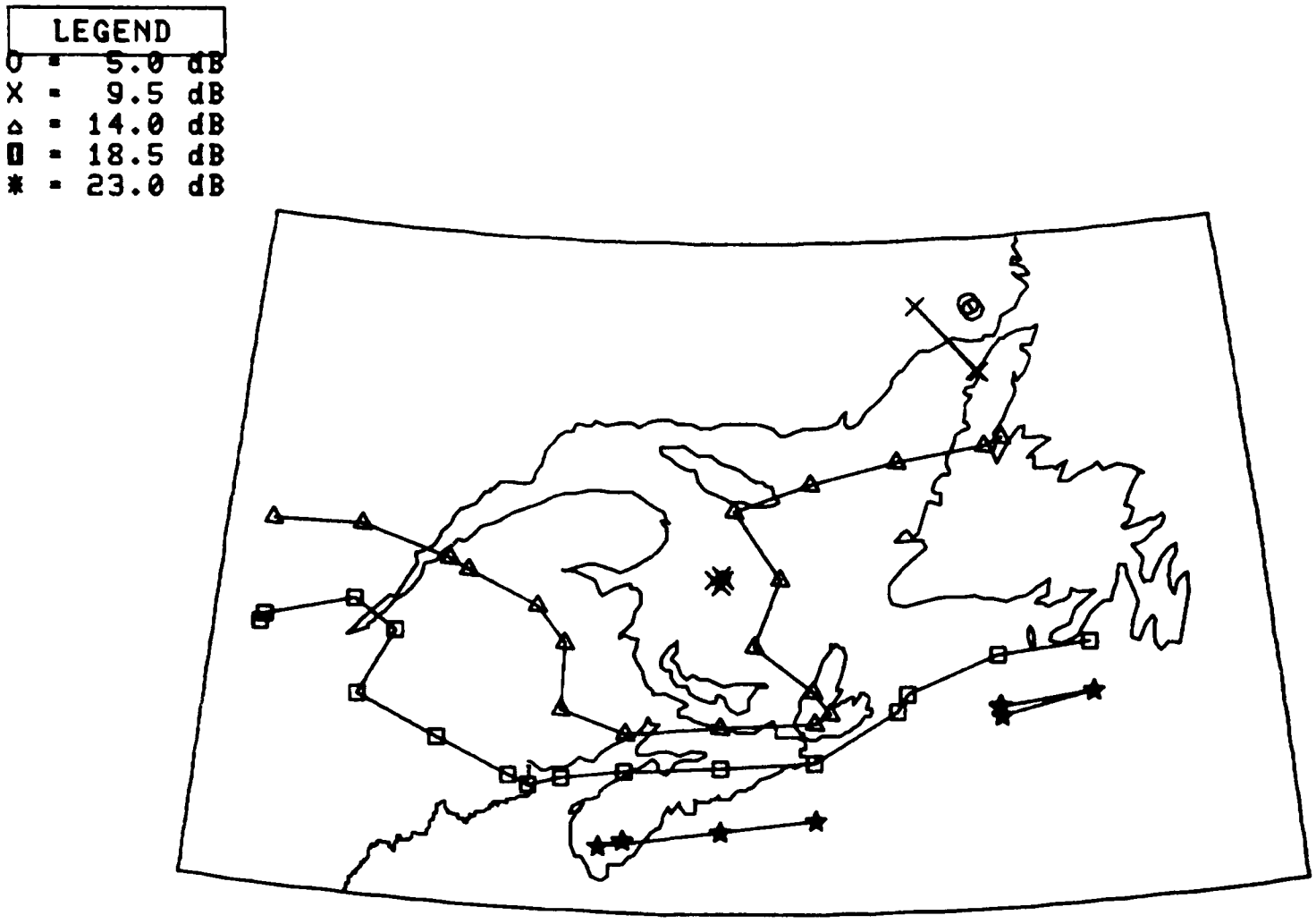
CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 2.26, 6.71 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 34



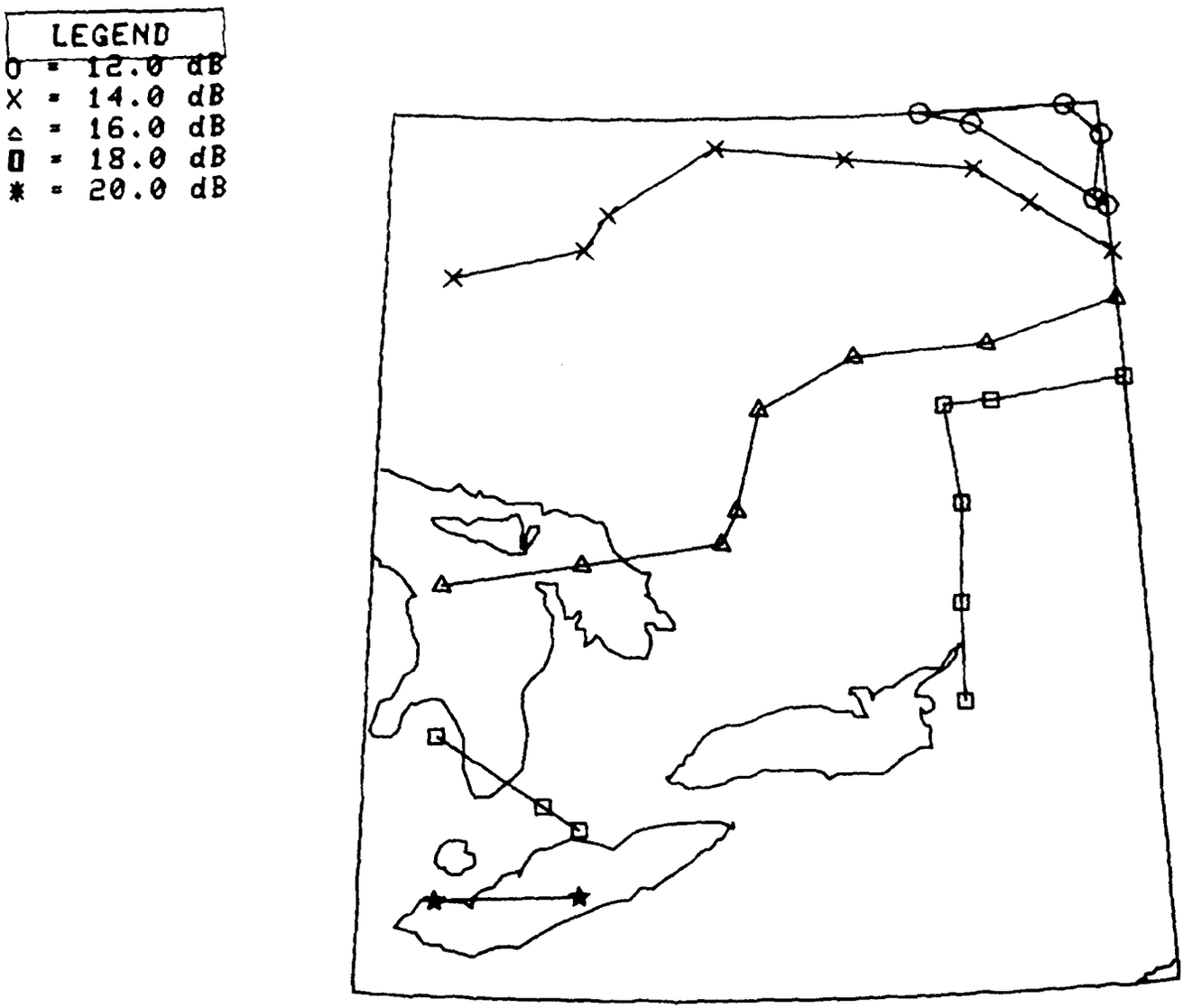
CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.500% OF YR MIN,MAX: 2.08,11.23 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 35



CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 4.57,24.72 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 36



CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX:11.43,20.23 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 37

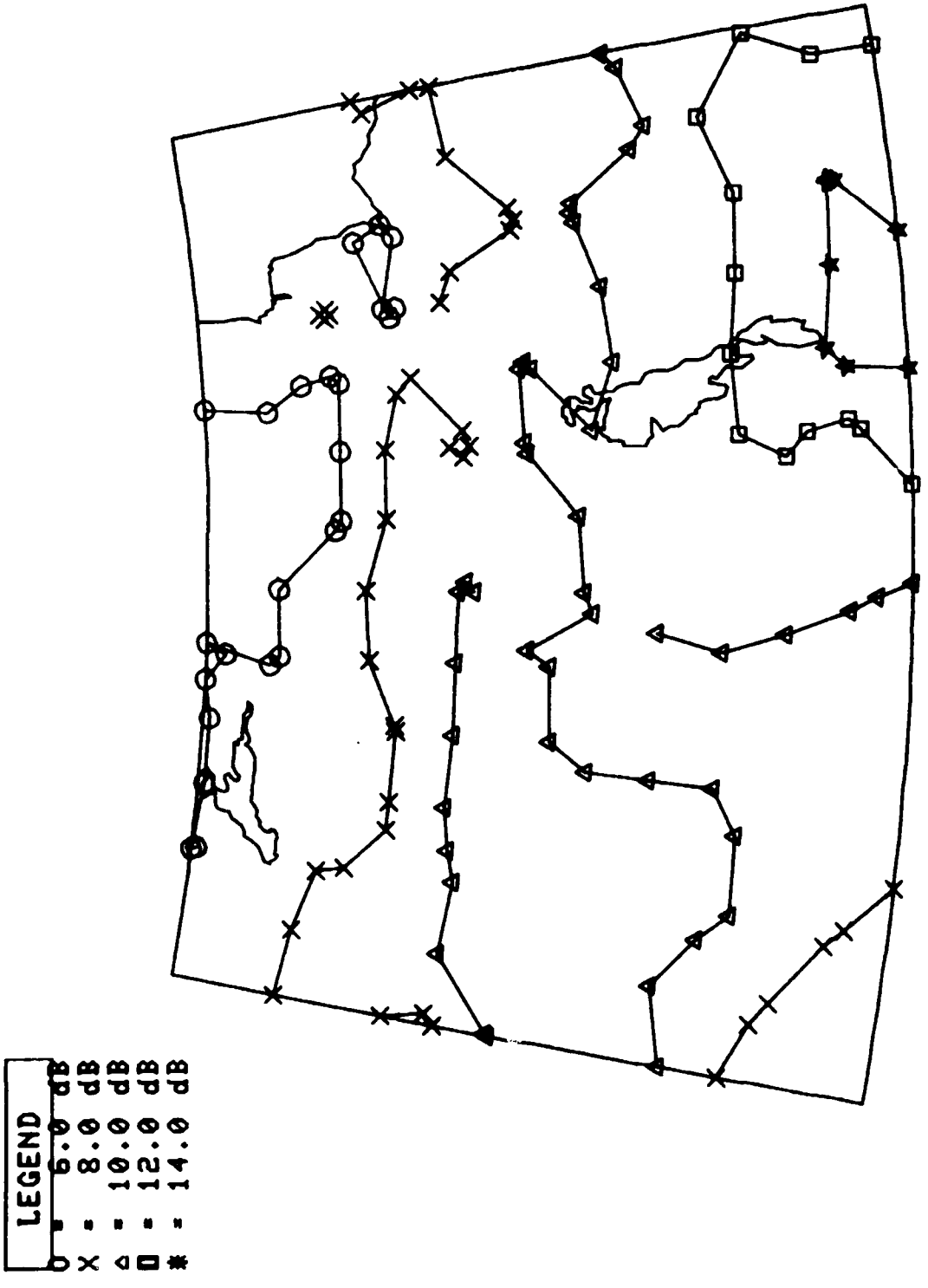
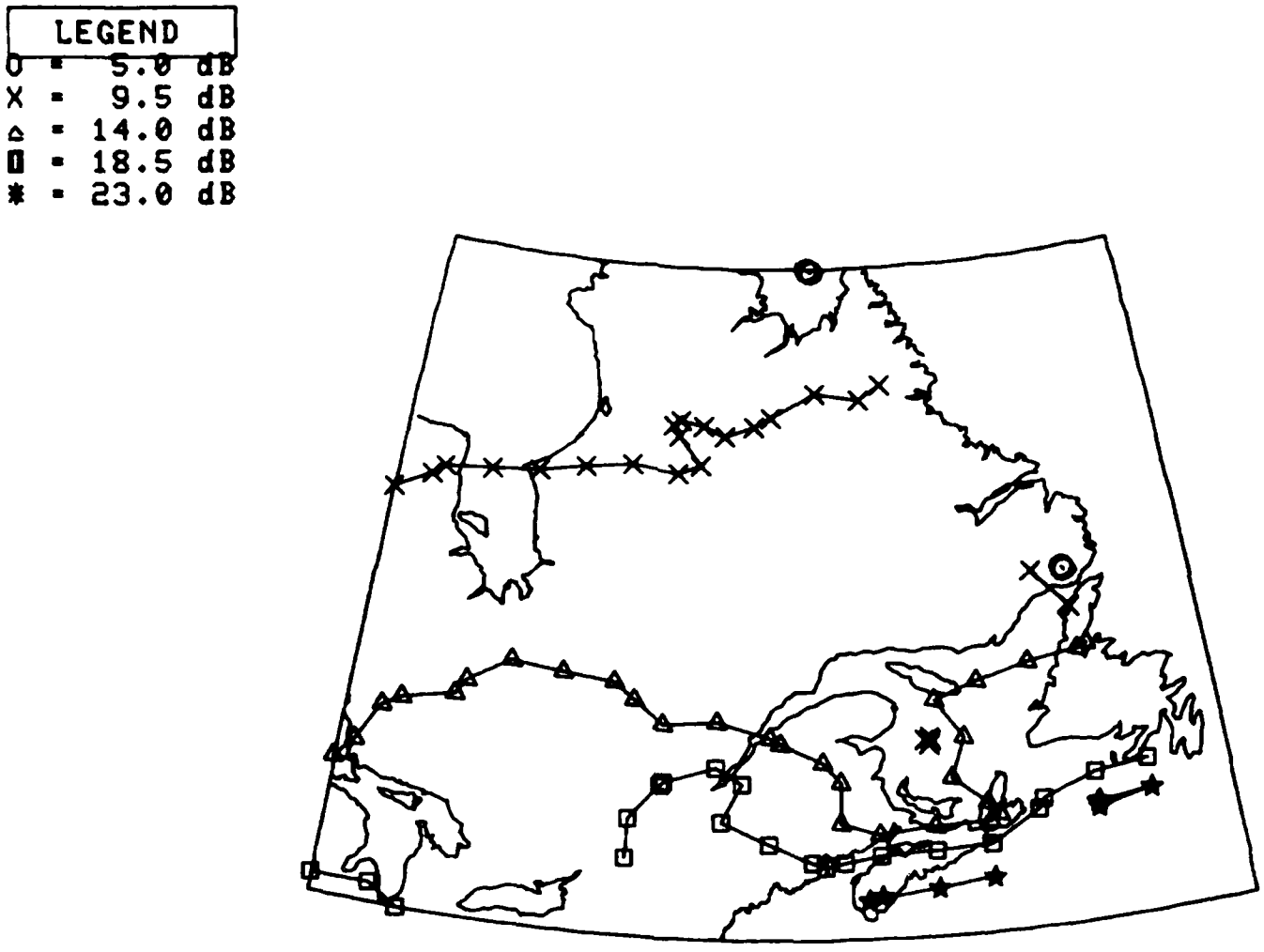

LEGEND
6.0 dB
8.0 dB
10.0 dB
12.0 dB
14.0 dB
CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 4.97,14.78 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 38



CANSLAM; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
EXCEEDANCE FOR 0.100% OF YR MIN,MAX: 4.57,24.72 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 39

Tables 3-50 (pages 67-114)	**Rain attenuation exceedance values for a major part of Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for the following values of P.**
	Attenuation exceedance values have been calculated at every degree of latitude in 41°N-70°N range and at every two degrees of longitude in 55°W-141°W range. Values of -1 or 0 indicate a lack of data at that point.
	The longitude of the satellite is 100° W and there is no site diversity. The min. and max. attenuation exceedance values over the region are also shown.
Frequency	**Percentage P of time of an average year when the rain attenuation exceeds the calculated attenuation value.**
20 GHz	(1) P = 0.1% ; (2) P = 0.01% .
30 GHz	(1) P = 0.5% ; (2) P = 0.1% .
44 GHz	(1) P = 0.5% ; (2) P = 0.1% .

Table 3

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 1.116, 8.506 (dB)

LATITUDE (DEG.)	73	71	69	67	65	63	61	59	57	55
55	2.65	2.91	2.98	3.05	3.06	2.87	2.96	-1.00	-1.00	-1.00
54	3.27	3.09	3.16	3.24	3.19	3.08	3.18	3.04	-1.00	-1.00
53	3.13	3.32	3.40	3.48	3.38	3.40	3.30	3.26	-1.00	-1.00
52	3.45	3.46	3.54	3.34	3.55	3.66	3.56	3.47	1.12	-1.00
51	3.50	3.19	3.26	3.67	3.41	3.64	3.75	3.73	2.65	-1.00
50	3.76	3.61	3.69	3.73	3.97	4.00	3.94	4.07	4.21	4.37
49	3.55	3.62	3.77	4.00	4.11	4.29	4.56	4.82	4.55	4.35
48	5.17	5.35	4.50	4.00	4.10	2.62	5.25	5.30	4.85	5.64
47	6.16	6.72	5.54	4.83	3.38	3.80	5.24	5.25	5.43	5.63
46	6.41	6.28	5.37	4.83	3.37	3.79	3.90	6.23	7.74	8.02
45	6.39	6.27	6.85	5.91	6.47	6.64	6.84	7.22	7.46	-1.00
44	-1.00	-1.00	6.85	7.44	8.05	8.27	8.51	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	7.44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 4

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site separation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extreme: Min, Max = 2.268, 6.964 (dB)

LATITUDE (DEG.)	93	91	89	87	85	83	81	79	77	75
55	2.27	2.55	2.57	2.30	2.32	2.59	2.63	2.66	2.71	2.76
54	3.07	2.70	2.72	2.58	2.60	2.91	2.94	2.99	3.15	3.20
53	3.71	2.77	3.10	2.73	3.05	3.09	3.13	3.48	3.53	3.39
52	3.49	3.72	3.75	3.12	3.15	3.18	3.54	3.59	3.65	3.58
51	4.04	4.06	3.74	3.14	3.30	3.64	3.68	3.63	3.64	3.70
50	4.55	4.05	3.52	3.76	3.63	3.81	3.85	4.31	4.04	3.49
49	4.38	4.05	3.52	3.94	4.09	4.36	4.41	4.85	5.00	5.08
48	-1.00	4.04	3.51	4.11	4.37	4.57	4.62	4.76	4.60	4.68
47	-1.00	-1.00	-1.00	4.33	4.37	4.84	4.90	4.97	5.95	6.05
46	-1.00	-1.00	-1.00	-1.00	4.64	5.03	5.10	5.16	5.95	6.04
45	-1.00	-1.00	-1.00	-1.00	5.16	5.34	5.41	5.43	5.95	6.05
44	-1.00	-1.00	-1.00	-1.00	5.66	5.72	5.79	5.61	5.95	6.05
43	-1.00	-1.00	-1.00	-1.00	6.80	6.87	5.79	5.87	5.95	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	6.88	6.96	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 5

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 2.015, 4.841 (dB)

LATITUDE (DEG.)	113	111	109	107	105	103	101	99	97	95
55	3.65	3.48	3.13	3.12	3.10	2.75	2.87	3.06	3.06	2.69
54	3.49	3.47	3.23	2.91	2.89	3.08	3.08	3.08	2.74	2.75
53	3.27	3.25	3.22	2.90	2.88	3.18	3.47	3.47	3.48	3.70
52	2.61	3.24	3.22	2.89	2.88	3.47	3.46	3.74	3.75	3.61
51	2.43	2.77	2.75	2.74	2.74	3.32	3.59	3.86	3.86	4.02
50	2.02	2.40	2.69	2.74	2.74	3.10	3.47	3.62	4.84	4.62
49	2.28	2.10	2.50	2.73	2.42	2.95	3.47	4.42	4.59	4.61
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 6

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 1.201, 3.528 (dB)

LATITUDE (DEG.)	133	131	129	127	125	123	121	119	117	115
55	-1.00	-1.00	-1.00	1.53	1.37	1.56	2.12	2.40	2.20	2.99
54	-1.00	-1.00	-1.00	-1.00	1.29	2.64	2.01	2.22	3.01	3.53
53	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.89	2.38	3.00	3.52
52	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.24	2.37	2.17	2.83
51	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.24	1.22	2.33	2.04
50	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.22	1.20	2.30
49	-1.00	-1.00	-1.00	-1.00	-1.00	2.09	-1.00	1.23	1.20	1.80
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 7

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ATT. TABLE
Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 0.738, 2.893 (dB)
```

LATITUDE (DEG.)	81	79	77	75	73	71	69	67	65	63
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
67	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
66	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
65	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
64	0.74	0.75	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
63	0.99	0.92	0.94	0.77	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
62	1.51	1.21	1.25	0.94	0.77	0.99	-1.00	-1.00	-1.00	-1.00
61	1.71	1.73	1.57	1.08	1.11	1.28	1.17	-1.00	-1.00	-1.00
60	2.06	1.90	1.55	1.42	1.42	2.08	1.89	1.18	-1.00	-1.00
59	2.04	2.19	1.82	1.57	2.02	2.06	2.17	2.12	2.18	-1.00
58	2.14	2.55	2.37	2.19	2.09	2.34	2.42	2.38	2.44	-1.00
57	2.50	2.32	2.52	2.33	2.45	2.59	2.65	2.72	2.67	2.75
56	2.51	2.55	2.67	2.57	2.82	2.72	2.78	2.85	2.81	2.89

Table 8

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 20.0 GHz
	Site diversity: N ; site seperation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.100
	Attenuation extrema: Min, Max = 0.506, 2.796 (dB)

LATITUDE (DEG.)	101	99	97	95	93	91	89	87	85	83
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	-1.00	-1.00	-1.00	0.52	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68-	0.65	0.51	0.65	0.51	0.51	0.51	-1.00	-1.00	-1.00	-1.00
67-	0.71	0.71	0.71	0.56	0.56	0.57	-1.00	-1.00	-1.00	-1.00
66-	0.94	0.80	0.80	0.64	0.81	0.65	-1.00	-1.00	-1.00	-1.00
65-	1.02	1.02	1.02	0.87	0.88	0.88	0.71	0.72	-1.00	-1.00
64-	1.06	1.06	1.22	1.15	1.15	1.16	0.96	0.71	0.72	0.73
63-	1.28	1.14	1.43	1.44	1.44	1.45	1.22	1.48	..24	1.26
62-	1.43	1.28	1.61	1.42	1.59	1.59	1.61	1.62	1.37	1.24
61-	1.25	1.42	1.60	1.56	1.78	1.79	1.59	1.61	1.62	1.64
60-	1.37	1.31	1.75	1.76	1.76	1.77	1.79	1.80	1.61	1.84
59-	1.57	1.47	1.74	1.74	1.93	1.94	1.95	1.97	1.99	2.01
58-	1.56	1.56	1.56	2.37	1.74	1.75	1.76	1.96	1.98	2.31
57-	2.54	2.54	2.25	1.55	1.56	1.97	2.39	2.41	2.44	2.47
56-	2.69	2.26	2.53	2.54	2.02	2.27	2.29	2.80	2.45	2.48

LONGITUDE (DEG.)

Table 9

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ATT. TABLE   Satellite located at 100.0 deg long;  Freq: 20.0 GHz
             Site diversity: N ; site separation dist. =  0.0 km
                               Baseline to path angle=  0.0 deg
             Percentage of year that values are exceeded: 0.100
             Attenuation extrema:  Min, Max =  0.647,  3.115 (dB)
```

LATITUDE (DEG.)	121	119	117	115	113	111	109	107	105	103
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	0.99	0.97	0.95	0.94	0.93	0.92	-1.00	0.79	-1.00	-1.00
68	1.07	1.17	1.15	1.13	1.01	1.00	0.99	0.77	0.77	0.65
67	1.31	1.29	1.27	1.25	1.12	1.11	1.10	1.03	0.90	0.90
66	1.40	1.50	1.48	1.46	1.33	1.19	1.18	1.17	1.04	1.03
65	1.58	1.55	1.53	1.51	1.31	1.37	1.23	1.22	1.22	1.02
64	1.80	1.77	1.74	1.72	1.48	1.58	1.34	1.21	1.20	1.20
63	1.88	1.86	1.83	1.70	1.68	1.67	1.55	1.42	1.29	1.28
62	1.83	1.81	1.78	1.66	1.77	1.63	1.64	1.52	1.40	1.44
61	1.91	1.66	1.68	1.66	1.64	1.63	1.60	1.50	1.49	1.38
60	1.91	1.88	1.78	2.05	2.03	1.61	1.60	1.59	1.67	1.47
59	1.95	1.98	1.89	2.12	2.10	1.84	1.91	2.04	1.57	1.57
58	1.92	2.01	1.88	2.39	2.37	2.30	2.28	2.27	2.03	2.12
57	2.03	2.17	2.14	2.36	2.34	2.32	2.30	2.29	2.55	2.54
56	2.13	2.21	2.38	2.18	2.97	2.95	3.12	3.10	3.08	3.08

Table 10

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site separation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 1.005, 1.937 (dB)

LATITUDE (DEG.)	141	139	137	135	133	131	129	127	125	123
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	1.83	1.75	1.68	1.62	1.57	1.52	1.48	1.45	1.41	1.00
68-	1.77	1.70	1.63	1.58	1.53	1.48	1.44	1.41	1.38	1.09
67-	1.72	1.65	1.59	1.54	1.49	1.60	1.56	1.52	1.49	1.34
66-	1.68	1.61	1.72	1.66	1.61	1.57	1.53	1.49	1.46	1.43
65-	-1.00	1.58	1.68	1.63	1.58	1.67	1.63	1.59	1.56	1.53
64-	-1.00	1.55	1.56	1.74	1.69	1.77	1.72	1.68	1.73	1.70
63-	-1.00	1.52	1.53	1.49	1.79	1.85	1.81	1.77	1.82	1.79
62-	-1.00	-1.00	1.63	1.58	1.74	1.94	1.89	1.85	1.81	1.78
61-	-1.00	-1.00	1.83	1.77	1.72	1.68	1.87	1.83	1.79	1.85
60-	-1.00	-1.00	-1.00	1.75	1.70	1.66	1.62	1.59	1.55	1.69
59-	-1.00	-1.00	-1.00	-1.00	1.69	1.65	1.61	1.57	1.63	1.76
58-	-1.00	-1.00	-1.00	-1.00	-1.00	1.63	1.59	1.56	1.61	1.82
57-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.58	1.63	1.48	1.88
56-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.62	1.53	1.70

LONGITUDE (DEG.)

Table 11

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site separation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.010
Attenuation extrema: Min, Max = 2.915, 22.218 (dB)

LATITUDE (DEG.)	73	71	69	67	65	63	61	59	57	55
55-	6.91	7.60	7.78	7.97	8.00	7.51	7.74	-1.00	-1.00	-1.00
54-	8.53	8.07	8.26	8.46	8.33	8.05	8.30	7.95	-1.00	-1.00
53-	8.18	8.67	8.87	9.09	8.82	8.89	8.63	8.53	-1.00	-1.00
52-	9.00	9.05	9.25	8.72	9.29	9.55	9.31	9.06	2.92	-1.00
51-	9.15	8.33	8.52	9.59	8.91	9.51	9.80	9.75	6.93	-1.00
50-	9.82	9.43	9.64	9.75	10.38	10.44	10.30	10.63	11.00	11.41
49-	9.27	9.45	9.85	10.46	10.73	11.20	11.91	12.58	11.90	11.36
48-	13.50	13.98	11.76	10.44	10.70	6.84	13.71	13.85	12.67	14.74
47-	16.09	17.55	14.48	12.62	8.82	9.92	13.68	13.71	14.18	14.69
46-	16.75	16.40	14.04	12.61	8.81	9.91	10.20	16.28	20.22	20.96
45-	16.70	16.39	17.90	15.44	16.90	17.35	17.85	18.87	19.50	-1.00
44-	-1.00	-1.00	17.90	19.44	21.03	21.60	22.22	-1.00	-1.00	-1.00
43-	-1.00	-1.00	-1.00	19.45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 12

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site separation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.010
Attenuation extrema: Min, Max = 5.924, 18.192 (dB)

LATITUDE (DEG.)	93	91	89	87	85	83	81	79	77	75
55	5.92	6.66	6.70	6.00	6.06	6.77	6.86	6.96	7.07	7.20
54	8.02	7.05	7.10	6.73	6.80	7.60	7.69	7.80	8.23	8.37
53	9.70	7.23	8.10	7.14	7.98	8.07	8.17	9.08	9.22	8.87
52	9.12	9.73	9.79	8.14	8.22	8.31	9.25	9.38	9.53	9.35
51	10.55	10.60	9.77	8.20	8.63	9.25	9.36	9.49	9.50	9.66
50	11.88	10.59	9.20	9.83	9.48	9.94	10.07	11.28	10.55	9.12
49	11.45	10.57	9.18	10.28	10.68	11.38	11.52	12.66	13.05	13.27
48	-1.00	10.56	9.18	10.72	11.41	11.93	12.08	12.44	12.82	12.22
47	-1.00	-1.00	-1.00	11.30	11.41	12.65	12.81	12.98	15.54	15.80
46	-1.00	-1.00	-1.00	-1.00	12.12	13.15	13.31	13.48	15.54	15.77
45	-1.00	-1.00	-1.00	-1.00	13.48	13.96	14.13	14.19	15.54	15.79
44	-1.00	-1.00	-1.00	-1.00	14.78	14.94	15.11	14.66	15.54	15.79
43	-1.00	-1.00	-1.00	-1.00	17.77	17.96	15.13	15.33	15.55	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	17.98	18.19	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 13

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.010
Attenuation extrema: Min, Max = 5.265, 12.844 (dB)

LATITUDE (DEG.)	113	111	109	107	105	103	101	99	97	95
55	9.53	9.09	8.18	8.14	8.10	7.20	7.51	7.99	8.00	7.01
54	9.13	9.05	8.45	7.59	7.56	8.05	8.04	8.04	7.17	7.19
53	8.55	8.48	8.42	7.57	7.53	8.32	9.07	9.07	9.09	9.66
52	6.83	8.46	8.40	7.54	7.51	9.06	9.05	9.78	9.79	9.44
51	6.34	7.24	7.20	7.16	7.16	8.67	9.38	10.07	10.09	10.51
50	5.26	6.27	7.03	7.14	7.15	8.10	9.06	9.46	12.64	12.06
49	5.95	5.49	6.52	7.14	8.31	7.72	9.05	11.54	11.99	12.04
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 14

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 20.0 GHz Site diversity: N ; site separation dist. = 0.0 km Baseline to path angle= 0.0 deg Percentage of year that values are exceeded: 0.010 Attenuation extrema: Min, Max = 3.136, 9.217 (dB)

LATITUDE (DEG.)	133	131	129	127	125	123	121	119	117	115
55	-1.00	-1.00	-1.00	4.00	3.59	4.08	5.55	6.26	5.74	7.80
54	-1.00	-1.00	-1.00	-1.00	3.37	6.89	5.24	5.79	7.86	9.22
53	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	4.93	6.21	7.83	9.18
52	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	3.24	6.19	5.68	7.39
51	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	3.23	3.19	6.09	5.32
50	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	3.18	3.14	6.02
49	-1.00	-1.00	-1.00	-1.00	-1.00	5.45	-1.00	3.21	3.14	4.71
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 15

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.010
Attenuation extrema: Min, Max = 1.927, 7.556 (dB)

LATITUDE (DEG.)	81	79	77	75	73	71	69	67	65	63
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
67	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
66	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
65	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
64	1.93	1.96	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
63	2.58	2.41	2.45	2.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
62	3.95	3.16	3.26	2.46	2.02	2.57	-1.00	-1.00	-1.00	-1.00
61	4.46	4.52	4.09	2.83	2.89	3.35	3.04	-1.00	-1.00	-1.00
60	5.37	4.96	4.05	3.70	3.72	5.44	4.95	3.09	-1.00	-1.00
59	5.33	5.72	4.74	4.09	5.27	5.39	5.67	5.55	5.71	-1.00
58	5.59	6.67	6.19	5.71	5.47	6.12	6.33	6.21	6.38	-1.00
57	6.53	6.05	6.59	6.08	6.40	6.76	6.92	7.09	6.98	7.19
56	6.56	6.66	6.98	6.71	7.38	7.10	7.27	7.45	7.34	7.56

LONGITUDE (DEG.)

Table 16

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 20.0 GHz
	Site diversity: N ; site separation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.010
	Attenuation extrema: Min, Max = 1.321, 7.305 (dB)

LATITUDE (DEG.)	101	99	97	95	93	91	89	87	85	83
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	-1.00	-1.00	-1.00	1.36	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68-	1.69	1.32	1.69	1.33	1.33	1.34	-1.00	-1.00	-1.00	-1.00
67-	1.85	1.85	1.85	1.47	1.48	1.49	-1.00	-1.00	-1.00	-1.00
66-	2.46	2.09	2.09	1.68	2.11	1.69	-1.00	-1.00	-1.00	-1.00
65-	2.65	2.66	2.66	2.28	2.29	2.31	1.87	1.88	-1.00	-1.00
64-	2.77	2.77	3.19	2.99	3.01	3.03	2.50	1.86	1.88	1.90
63-	3.34	2.98	3.74	3.75	3.77	3.79	3.18	3.86	3.25	3.29
62-	3.75	3.36	4.22	3.71	4.14	4.17	4.20	4.23	3.59	3.25
61-	3.28	3.71	4.17	4.08	4.65	4.67	4.16	4.19	4.24	4.29
60-	3.58	3.42	4.58	4.59	4.61	4.63	4.67	4.71	4.20	4.81
59-	4.09	3.83	4.54	4.56	5.03	5.06	5.10	5.14	5.20	5.26
58-	4.07	4.07	4.07	6.19	4.54	4.57	4.60	5.11	5.16	6.04
57-	6.63	6.63	5.89	4.06	4.08	5.14	6.25	6.31	6.37	6.44
56-	7.02	5.90	6.60	6.62	5.28	5.93	5.97	7.30	6.40	6.48

LONGITUDE (DEG.)

Table 17

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 20.0 GHz Site diversity: N ; site seperation dist. = 0.0 km Baseline to path angle= 0.0 deg Percentage of year that values are exceeded: 0.010 Attenuation extrema: Min, Max = 1.689, 8.137 (dB)

LATITUDE (DEG.)	121	119	117	115	113	111	109	107	105	103
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	2.57	2.53	2.49	2.46	2.43	2.40	-1.00	2.07	-1.00	-1.00
68	2.78	3.04	3.00	2.96	2.63	2.60	2.58	2.02	2.01	1.69
67	3.43	3.37	3.32	3.28	2.93	2.90	2.88	2.68	2.35	2.35
66	3.66	3.92	3.86	3.81	3.47	3.11	3.09	3.07	2.71	2.70
65	4.13	4.06	4.00	3.95	3.41	3.57	3.22	3.20	3.18	2.66
64	4.70	4.62	4.56	4.50	3.86	4.12	3.49	3.15	3.14	3.13
63	4.92	4.85	4.78	4.44	4.40	4.36	4.04	3.71	3.36	3.35
62	4.79	4.72	4.65	4.35	4.62	4.26	4.28	3.97	3.65	3.75
61	4.98	4.33	4.39	4.33	4.29	4.25	4.19	3.91	3.90	3.60
60	4.99	4.92	4.66	5.35	5.30	4.21	4.18	4.16	4.35	3.85
59	5.08	5.18	4.94	5.55	5.49	4.79	5.00	5.32	4.11	4.10
58	5.01	5.25	4.92	6.25	6.19	6.00	5.96	5.92	5.32	5.55
57	5.29	5.66	5.59	6.17	6.11	6.06	6.02	5.98	6.66	6.64
56	5.56	5.77	6.21	5.71	7.77	7.70	8.14	8.09	8.06	8.04

LONGITUDE (DEG.)

Table 18

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.010
Attenuation extrema: Min, Max = 2.624, 5.060 (dB)

LATITUDE (DEG.)	141	139	137	135	133	131	129	127	125	123
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	4.77	4.57	4.40	4.24	4.10	3.98	3.87	3.78	3.69	2.62
68	4.62	4.43	4.27	4.12	3.99	3.88	3.77	3.68	3.60	2.84
67	4.49	4.31	4.16	4.02	3.90	4.18	4.07	3.97	3.88	3.49
66	4.38	4.21	4.49	4.34	4.21	4.09	3.98	3.89	3.80	3.73
65	-1.00	4.13	4.40	4.26	4.13	4.36	4.25	4.15	4.06	3.99
64	-1.00	4.05	4.08	4.55	4.41	4.61	4.50	4.39	4.53	4.44
63	-1.00	3.98	4.01	3.88	4.67	4.84	4.72	4.62	4.75	4.68
62	-1.00	-1.00	4.26	4.13	4.56	5.06	4.94	4.83	4.73	4.64
61	-1.00	-1.00	4.78	4.63	4.50	4.39	4.88	4.77	4.68	4.83
60	-1.00	-1.00	-1.00	4.58	4.45	4.34	4.24	4.14	4.06	4.42
59	-1.00	-1.00	-1.00	-1.00	4.41	4.30	4.20	4.11	4.25	4.59
58	-1.00	-1.00	-1.00	-1.00	-1.00	4.26	4.16	4.07	4.22	4.75
57	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	4.13	4.27	3.83	4.91
56	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	4.24	3.99	4.44

Table 19

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 1.102, 7.303 (dB)

LATITUDE (DEG.)	73	71	69	67	65	63	61	59	57	55
55	2.44	2.67	2.73	2.80	2.81	2.65	2.73	-1.00	-1.00	-1.00
54	2.96	2.82	2.88	2.95	2.91	2.83	2.92	2.81	-1.00	-1.00
53	2.85	3.01	3.08	3.16	3.07	3.10	3.03	3.00	-1.00	-1.00
52	3.11	3.13	3.20	3.04	3.23	3.32	3.24	3.17	1.10	-1.00
51	3.16	2.90	2.96	3.32	3.10	3.30	3.40	3.40	2.47	-1.00
50	3.38	3.26	3.33	3.37	3.58	3.60	3.56	3.68	3.81	3.95
49	3.20	3.26	3.39	3.60	3.69	3.85	4.08	4.30	4.10	3.93
48	4.54	4.70	4.00	3.59	3.68	2.43	4.65	4.71	4.34	5.01
47	5.35	5.81	4.86	4.28	3.07	3.43	4.64	4.66	4.82	5.00
46	5.56	5.45	4.72	4.28	3.07	3.43	3.53	5.47	6.72	6.96
45	5.54	5.45	5.93	5.17	5.63	5.79	5.95	6.28	6.49	-1.00
44	-1.00	-1.00	5.93	6.41	6.91	7.10	7.30	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	6.41	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 20

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 2.092, 5.979 (dB)

LATITUDE (DEG.)	93	91	89	87	85	83	81	79	77	75
55	2.09	2.33	2.35	2.12	2.14	2.38	2.41	2.44	2.48	2.53
54	2.78	2.46	2.48	2.36	2.38	2.64	2.68	2.72	2.86	2.91
53	3.31	2.52	2.80	2.49	2.77	2.80	2.83	3.13	3.18	3.07
52	3.13	3.32	3.35	2.82	2.84	2.87	3.18	3.22	3.27	3.22
51	3.58	3.60	3.34	2.84	2.97	3.18	3.22	3.26	3.27	3.32
50	4.00	3.59	3.15	3.36	3.25	3.40	3.44	3.82	3.60	3.15
49	3.87	3.59	3.15	3.50	3.63	3.85	3.90	4.26	4.39	4.47
48	-1.00	3.59	3.15	3.64	3.86	4.03	4.08	4.20	4.07	4.13
47	-1.00	-1.00	-1.00	3.82	3.86	4.26	4.31	4.37	5.17	5.28
46	-1.00	-1.00	-1.00	-1.00	4.08	4.41	4.46	4.52	5.17	5.25
45	-1.00	-1.00	-1.00	-1.00	4.51	4.66	4.72	4.74	5.17	5.25
44	-1.00	-1.00	-1.00	-1.00	4.92	4.97	5.03	4.89	5.17	5.25
43	-1.00	-1.00	-1.00	-1.00	5.84	5.90	5.03	5.10	5.17	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	5.91	5.98	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 21

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz Site diversity: N ; site separation dist. = 0.0 km Baseline to path angle= 0.0 deg Percentage of year that values are exceeded: 0.500 Attenuation extrema: Min, Max = 1.874, 4.240 (dB)

LATITUDE (DEG.)	113	111	109	107	105	103	101	99	97	95
55	3.26	3.12	2.83	2.81	2.80	2.51	2.61	2.76	2.77	2.45
54	3.14	3.11	2.91	2.64	2.63	2.78	2.78	2.78	2.50	2.50
53	2.95	2.92	2.90	2.63	2.62	2.87	3.11	3.11	3.12	3.30
52	2.39	2.92	2.90	2.62	2.61	3.11	3.10	3.34	3.34	3.23
51	2.23	2.52	2.51	2.49	2.49	2.98	3.21	3.43	3.43	3.57
50	1.87	2.21	2.45	2.49	2.49	2.80	3.11	3.23	4.24	4.06
49	2.10	1.95	2.29	2.49	2.22	2.67	3.10	3.89	4.04	4.05
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 22

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 1.157, 3.166 (dB)

LATITUDE (DEG.)	133	131	129	127	125	123	121	119	117	115
55	-1.00	-1.00	-1.00	1.46	1.32	1.48	1.98	2.21	2.04	2.71
54	-1.00	-1.00	-1.00	-1.00	1.24	2.42	1.87	2.05	2.73	3.17
53	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.77	2.19	2.72	3.15
52	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.20	2.18	2.02	2.57
51	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.19	1.18	2.15	1.90
50	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.17	1.16	2.12
49	-1.00	-1.00	-1.00	-1.00	-1.00	1.94	-1.00	1.18	1.16	1.69
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 23

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 0.739, 2.669 (dB)

LATITUDE (DEG.)	81	79	77	75	73	71	69	67	65	63
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
67	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
66	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
65	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
64	0.74	0.75	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
63	0.97	0.91	0.93	0.77	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
62	1.44	1.17	1.21	0.93	0.77	0.97	-1.00	-1.00	-1.00	-1.00
61	1.61	1.64	1.49	1.06	1.08	1.25	1.14	-1.00	-1.00	-1.00
60	1.92	1.78	1.48	1.36	1.37	1.95	1.79	1.16	-1.00	-1.00
59	1.98	2.04	1.71	1.49	1.89	1.94	2.03	2.00	2.05	-1.00
58	1.99	2.35	2.19	2.04	1.96	2.18	2.25	2.22	2.28	-1.00
57	2.30	2.14	2.32	2.16	2.27	2.39	2.45	2.51	2.48	2.55
56	2.31	2.34	2.45	2.37	2.59	2.50	2.56	2.62	2.59	2.67

LONGITUDE (DEG.)

Table 24

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz
	Site diversity: N ; site seperation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.500
	Attenuation extrema: Min, Max = 0.520, 2.548 (dB)

LATITUDE (DEG.)	101	99	97	95	93	91	89	87	85	83
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	0.53	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	0.65	0.52	0.65	0.52	0.52	0.53	-1.00	-1.00	-1.00	-1.00
67	0.71	0.71	0.71	0.57	0.58	0.58	-1.00	-1.00	-1.00	-1.00
66	0.92	0.80	0.80	0.65	0.80	0.65	-1.00	-1.00	-1.00	-1.00
65	0.99	0.99	0.99	0.86	0.87	0.87	0.72	0.72	-1.00	-1.00
64	1.03	1.03	1.18	1.11	1.12	1.12	0.94	0.71	0.72	0.73
63	1.23	1.11	1.37	1.37	1.38	1.39	1.18	1.41	1.20	1.21
62	1.37	1.23	1.53	1.36	1.50	1.51	1.52	1.54	1.32	1.20
61	1.21	1.35	1.51	1.48	1.67	1.68	1.51	1.52	1.54	1.55
60	1.31	1.25	1.65	1.65	1.66	1.67	1.68	1.69	1.52	1.73
59	1.48	1.39	1.63	1.64	1.80	1.81	1.82	1.84	1.86	1.88
58	1.47	1.47	1.47	2.18	1.63	1.64	1.66	1.83	1.84	2.14
57	2.32	2.32	2.08	1.47	1.48	1.83	2.20	2.22	2.24	2.27
56	2.45	2.08	2.31	2.32	1.88	2.10	2.11	2.55	2.25	2.28

LONGITUDE (DEG.)

Table 25

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz Site diversity: N ; site seperation dist. = 0.0 km Baseline to path angle= 0.0 deg Percentage of year that values are exceeded: 0.500 Attenuation extrema: Min, Max = 0.654, 2.815 (dB)

LATITUDE (DEG.)	121	119	117	115	113	111	109	107	105	103
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	0.98	0.96	0.94	0.93	0.92	0.91	-1.00	0.79	-1.00	-1.00
68-	1.05	1.14	1.12	1.11	0.99	0.98	0.97	0.77	0.77	0.65
67-	1.27	1.25	1.23	1.22	1.09	1.08	1.07	1.01	0.89	0.89
66-	1.35	1.44	1.42	1.40	1.28	1.16	1.15	1.14	1.01	1.01
65-	1.51	1.48	1.46	1.44	1.26	1.31	1.19	1.18	1.18	0.99
64-	1.70	1.67	1.65	1.63	1.41	1.50	1.28	1.17	1.16	1.16
63-	1.78	1.75	1.72	1.61	1.59	1.58	1.47	1.36	1.24	1.23
62-	1.73	1.70	1.68	1.58	1.67	1.54	1.55	1.44	1.33	1.37
61-	1.79	1.57	1.59	1.57	1.55	1.54	1.52	1.48	1.42	1.32
60-	1.80	1.77	1.68	1.91	1.89	1.53	1.52	1.51	1.57	1.40
59-	1.82	1.86	1.77	1.97	1.95	1.72	1.79	1.90	1.49	1.48
58-	1.80	1.88	1.77	2.21	2.19	2.12	2.11	2.09	1.89	1.97
57-	1.89	2.01	1.99	2.18	2.16	2.14	2.12	2.11	2.33	2.33
56-	1.98	2.05	2.19	2.08	2.70	2.68	2.82	2.80	2.79	2.78

LONGITUDE (DEG.)

Table 26

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz
	Site diversity: N ; site seperation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.500
	Attenuation extrema: Min, Max = 0.995, 1.833 (dB)

LATITUDE (DEG.)	141	139	137	135	133	131	129	127	125	123
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	1.77	1.70	1.63	1.57	1.52	1.48	1.44	1.40	1.37	0.99
68-	1.72	1.65	1.58	1.53	1.48	1.44	1.40	1.37	1.33	1.07
67-	1.67	1.60	1.54	1.49	1.45	1.54	1.50	1.46	1.43	1.29
66-	1.63	1.56	1.66	1.60	1.55	1.51	1.47	1.43	1.40	1.38
65-	-1.00	1.53	1.62	1.57	1.52	1.60	1.56	1.52	1.49	1.46
64-	-1.00	1.50	1.51	1.67	1.62	1.68	1.64	1.60	1.65	1.62
63-	-1.00	1.48	1.48	1.44	1.70	1.76	1.72	1.68	1.72	1.69
62-	-1.00	-1.00	1.57	1.52	1.67	1.83	1.79	1.75	1.71	1.68
61-	-1.00	-1.00	1.75	1.69	1.64	1.60	1.77	1.73	1.69	1.74
60-	-1.00	-1.00	-1.00	1.67	1.63	1.59	1.55	1.51	1.48	1.60
59-	-1.00	-1.00	-1.00	-1.00	1.61	1.57	1.53	1.50	1.55	1.66
58-	-1.00	-1.00	-1.00	-1.00	-1.00	1.56	1.52	1.49	1.54	1.71
57-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.51	1.55	1.40	1.77
56-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	1.54	1.46	1.61

LONGITUDE (DEG.)

Table 27

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 2.425, 16.070 (dB)

LATITUDE (DEG.)	73	71	69	67	65	63	61	59	57	55
55	5.36	5.87	6.00	6.15	6.18	5.83	6.02	-1.00	-1.00	-1.00
54	6.52	6.20	6.34	6.50	6.41	6.22	6.42	6.18	-1.00	-1.00
53	6.27	6.63	6.78	6.94	6.77	6.83	6.66	6.59	-1.00	-1.00
52	6.85	6.89	7.05	6.68	7.10	7.30	7.14	6.98	2.43	-1.00
51	6.96	6.38	6.52	7.30	6.83	7.27	7.49	7.47	5.45	-1.00
50	7.43	7.17	7.32	7.41	7.87	7.93	7.84	8.10	8.38	8.69
49	7.04	7.18	7.47	7.91	8.12	8.47	8.98	9.47	9.01	8.65
48	10.00	10.34	8.81	7.90	8.10	5.34	10.24	10.36	9.56	11.03
47	11.78	12.79	10.70	9.43	6.76	7.56	10.22	10.26	10.61	11.00
46	12.23	12.00	10.40	9.42	6.75	7.55	7.77	12.05	14.78	15.32
45	12.20	12.00	13.05	11.38	12.40	12.73	13.10	13.82	14.29	-1.00
44	-1.00	-1.00	13.04	14.11	15.21	15.62	16.07	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	14.12	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 28

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz Site diversity: N ; site seperation dist. = 0.0 km Baseline to path angle= 0.0 deg Percentage of year that values are exceeded: 0.100 Attenuation extrema: Min, Max = 4.603, 13.156 (dB)

LATITUDE (DEG.)	93	91	89	87	85	83	81	79	77	75
55	4.60	5.13	5.17	4.66	4.71	5.23	5.30	5.37	5.46	5.56
54	6.11	5.42	5.46	5.19	5.24	5.82	5.89	5.98	6.29	6.40
53	7.29	5.54	6.16	5.48	6.09	6.16	6.23	6.89	7.00	6.75
52	6.88	7.31	7.36	6.20	6.26	6.32	7.00	7.10	7.21	7.09
51	7.88	7.92	7.34	6.24	6.55	6.99	7.08	7.18	7.19	7.31
50	8.80	7.91	6.94	7.39	7.15	7.48	7.57	8.42	7.93	6.92
49	8.51	7.90	6.93	7.70	7.99	8.48	8.59	9.39	9.67	9.83
48	-1.00	7.89	6.92	8.01	8.50	8.87	8.97	9.24	8.85	9.10
47	-1.00	-1.00	-1.00	8.42	8.49	9.36	9.48	9.61	11.38	11.57
46	-1.00	-1.00	-1.00	-1.00	8.99	9.71	9.82	9.96	11.37	11.54
45	-1.00	-1.00	-1.00	-1.00	9.93	10.26	10.39	10.44	11.37	11.56
44	-1.00	-1.00	-1.00	-1.00	10.82	10.93	11.06	10.76	11.38	11.56
43	-1.00	-1.00	-1.00	-1.00	12.85	12.99	11.07	11.22	11.38	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	13.00	13.16	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 29

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz
	Site diversity: N ; site seperation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.100
	Attenuation extrema: Min, Max = 4.124, 9.331 (dB)

LATITUDE (DEG.)	113	111	109	107	105	103	101	99	97	95
55	7.18	6.87	6.22	6.19	6.17	5.52	5.74	6.08	6.09	5.39
54	6.90	6.84	6.41	5.80	5.78	6.12	6.12	6.12	5.50	5.51
53	6.49	6.44	6.39	5.78	5.76	6.31	6.85	6.85	6.86	7.26
52	5.26	6.42	6.37	5.77	5.74	6.84	6.83	7.34	7.35	7.10
51	4.90	5.55	5.52	5.49	5.49	6.56	7.06	7.55	7.56	7.85
50	4.12	4.85	5.40	5.48	5.48	6.16	6.84	7.12	9.33	8.93
49	4.62	4.29	5.03	5.47	4.87	5.88	6.83	8.57	8.88	8.92
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 30

```
ATT. TABLE | Satellite located at 100.0 deg long; Freq: 30.0 GHz
           | Site diversity: N ; site seperation dist. =  0.0 km
           |                     Baseline to path angle=  0.0 deg
           | Percentage of year that values are exceeded: 0.100
           | Attenuation extrema:  Min, Max =  2.546,  6.967 (dB)
```

LATITUDE (DEG.)	133	131	129	127	125	123	121	119	117	115
55	-1.00	-1.00	-1.00	3.21	2.90	3.27	4.35	4.86	4.48	5.97
54	-1.00	-1.00	-1.00	-1.00	2.74	5.33	4.12	4.52	6.01	6.97
53	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	3.89	4.82	5.99	6.94
52	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.63	4.81	4.44	5.67
51	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.62	2.59	4.74	4.17
50	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.58	2.55	4.67
49	-1.00	-1.00	-1.00	-1.00	-1.00	4.28	-1.00	2.60	2.55	3.72
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 31

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz
	Site diversity: N ; site seperation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.100
	Attenuation extrema: Min, Max = 1.627, 5.874 (dB)

LATITUDE (DEG.)	81	79	77	75	73	71	69	67	65	63
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
67	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
66	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
65	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
64	1.63	1.65	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
63	2.14	2.00	2.04	1.69	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
62	3.18	2.58	2.66	2.05	1.71	2.14	-1.00	-1.00	-1.00	-1.00
61	3.55	3.60	3.29	2.33	2.38	2.74	2.61	-1.00	-1.00	-1.00
60	4.22	3.92	3.26	2.99	3.01	4.30	3.94	2.55	-1.00	-1.00
59	4.19	4.48	3.77	3.29	4.17	4.26	4.47	4.39	4.52	-1.00
58	4.38	5.17	4.83	4.48	4.31	4.79	4.95	4.88	5.01	-1.00
57	5.06	4.72	5.11	4.75	4.99	5.26	5.38	5.52	5.45	5.61
56	5.08	5.16	5.40	5.21	5.70	5.60	5.63	5.77	5.71	5.87

LONGITUDE (DEG.)

Table 32

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz
	Site diversity: N ; site seperation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.100
	Attenuation extrema: Min, Max = 1.143, 5.607 (dB)

LATITUDE (DEG.)	101	99	97	95	93	91	89	87	85	83
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	-1.00	-1.00	-1.00	1.17	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68-	1.44	1.14	1.44	1.15	1.15	1.16	-1.00	-1.00	-1.00	-1.00
67-	1.56	1.56	1.57	1.26	1.27	1.28	-1.00	-1.00	-1.00	-1.00
66-	2.03	1.75	1.75	1.42	1.77	1.44	-1.00	-1.00	-1.00	-1.00
65-	2.18	2.18	2.19	1.90	1.91	1.92	1.57	1.59	-1.00	-1.00
64-	2.28	2.28	2.59	2.44	2.46	2.47	2.07	1.57	1.58	1.60
63-	2.71	2.43	3.00	3.02	3.03	3.05	2.59	3.10	2.64	2.67
62-	3.01	2.71	3.36	2.98	3.31	3.33	3.35	3.38	2.90	2.64
61-	2.65	2.98	3.33	3.26	3.68	3.70	3.32	3.35	3.38	3.42
60-	2.88	2.76	3.62	3.63	3.65	3.67	3.69	3.73	3.35	3.81
59-	3.26	3.07	3.60	3.61	3.96	3.98	4.01	4.05	4.09	4.13
58-	3.24	3.24	3.24	4.80	3.60	3.62	3.64	4.02	4.06	4.70
57-	5.11	5.11	4.58	3.23	3.25	4.04	4.85	4.89	4.94	5.00
56-	5.39	4.59	5.09	5.11	4.13	4.21	4.64	5.61	4.98	5.02

LONGITUDE (DEG.)

Table 33

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 1.438, 6.195 (dB)

LATITUDE (DEG.)	121	119	117	115	113	111	109	107	105	103
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	2.15	2.11	2.08	2.05	2.03	2.01	-1.00	1.74	-1.00	-1.00
68	2.31	2.50	2.47	2.43	2.18	2.16	2.14	1.70	1.70	1.44
67	2.80	2.75	2.71	2.67	2.40	2.38	2.36	2.22	1.96	1.95
66	2.97	3.16	3.12	3.08	2.81	2.54	2.52	2.51	2.23	2.22
65	3.32	3.27	3.22	3.18	2.77	2.89	2.62	2.60	2.59	2.19
64	3.74	3.68	3.63	3.59	3.10	3.30	2.83	2.57	2.55	2.55
63	3.91	3.85	3.79	3.54	3.50	3.47	3.23	2.98	2.72	2.71
62	3.81	3.75	3.70	3.47	3.67	3.40	3.41	3.18	2.94	3.01
61	3.94	3.45	3.50	3.45	3.42	3.39	3.34	3.13	3.12	2.90
60	3.95	3.89	3.70	4.20	4.16	3.36	3.33	3.32	3.46	3.08
59	4.01	4.08	3.90	4.34	4.30	3.79	3.93	4.17	3.28	3.27
58	3.96	4.13	3.89	4.86	4.81	4.67	4.63	4.61	4.16	4.33
57	4.16	4.43	4.38	4.79	4.75	4.71	4.67	4.65	5.13	5.12
56	4.36	4.51	4.82	4.46	5.94	5.89	6.19	6.16	6.14	6.12

Table 34

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 30.0 GHz
	Site diversity: N ; site separation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.100
	Attenuation extrema: Min, Max = 2.190, 4.033 (dB)

LATITUDE (DEG.)	141	139	137	135	133	131	129	127	125	123
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	3.90	3.74	3.59	3.46	3.35	3.25	3.16	3.08	3.01	2.19
68-	3.77	3.62	3.49	3.37	3.26	3.17	3.08	3.01	2.94	2.35
67-	3.67	3.52	3.40	3.29	3.19	3.39	3.30	3.22	3.15	2.85
66-	3.58	3.44	3.65	3.52	3.42	3.32	3.23	3.16	3.09	3.03
65-	-1.00	3.37	3.57	3.45	3.35	3.52	3.43	3.35	3.28	3.22
64-	-1.00	3.31	3.32	3.67	3.56	3.71	3.61	3.53	3.63	3.56
63-	-1.00	3.25	3.27	3.16	3.75	3.88	3.78	3.69	3.79	3.72
62-	-1.00	-1.00	3.46	3.35	3.66	4.03	3.93	3.85	3.77	3.70
61-	-1.00	-1.00	3.84	3.72	3.62	3.53	3.89	3.80	3.73	3.84
60-	-1.00	-1.00	-1.00	3.68	3.58	3.49	3.41	3.33	3.26	3.53
59-	-1.00	-1.00	-1.00	-1.00	3.54	3.45	3.37	3.30	3.40	3.65
58-	-1.00	-1.00	-1.00	-1.00	-1.00	3.43	3.35	3.27	3.38	3.77
57-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	3.32	3.42	3.08	3.89
56-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	3.40	3.20	3.54

LONGITUDE (DEG.)

Table 35

```
ATT. TABLE | Satellite located at 100.0 deg long; Freq: 44.0 GHz
           | Site diversity: N ; site seperation dist. = 0.0 km
           |                     Baseline to path angle= 0.0 deg
           | Percentage of year that values are exceeded: 0.500
           | Attenuation extrema: Min, Max = 2.078, 11.232 (dB)
```

LATITUDE (DEG.)	73	71	69	67	65	63	61	59	57	55
55	4.14	4.50	4.61	4.72	4.75	4.53	4.67	-1.00	-1.00	-1.00
54	4.94	4.73	4.84	4.96	4.91	4.80	4.95	4.80	-1.00	-1.00
53	4.77	5.02	5.13	5.26	5.15	5.21	5.11	5.08	-1.00	-1.00
52	5.16	5.20	5.31	5.08	5.37	5.53	5.44	5.34	2.08	-1.00
51	5.23	4.85	4.96	5.49	5.19	5.50	5.67	5.68	4.29	-1.00
50	5.54	5.38	5.50	5.57	5.89	5.95	5.91	6.10	6.31	6.55
49	5.28	5.39	5.59	5.90	6.06	6.31	6.67	7.02	6.74	6.52
48	7.23	7.47	6.48	5.89	6.04	4.17	7.50	7.60	7.10	8.10
47	8.38	9.04	7.72	6.91	5.14	5.69	7.49	7.54	7.80	8.08
46	8.66	8.54	7.52	6.90	5.13	5.69	5.85	8.70	10.49	10.87
45	8.64	8.53	9.22	8.17	8.85	9.09	9.35	9.84	10.17	-1.00
44	-1.00	-1.00	9.22	9.92	10.63	10.92	11.23	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	9.92	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 36

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 44.0 GHz
	Site diversity: N ; site seperation dist. = 0.0 km
	Baseline to path angle= 0.0 deg
	Percentage of year that values are exceeded: 0.500
	Attenuation extrema: Min, Max = 3.570, 9.193 (dB)

LATITUDE (DEG.)	93	91	89	87	85	83	81	79	77	75
55-	3.57	3.94	3.97	3.62	3.65	4.02	4.07	4.13	4.20	4.27
54-	4.60	4.13	4.16	3.98	4.02	4.42	4.48	4.54	4.76	4.84
53-	5.39	4.22	4.64	4.18	4.60	4.65	4.71	5.16	5.24	5.08
52-	5.12	5.40	5.44	4.67	4.71	4.76	5.22	5.29	5.38	5.31
51-	5.78	5.81	5.43	4.69	4.91	5.21	5.27	5.35	5.36	5.45
50-	6.38	5.80	5.16	5.46	5.31	5.53	5.60	6.17	5.85	5.19
49-	6.19	5.79	5.15	5.67	5.86	6.19	6.27	6.80	6.99	7.11
48-	-1.00	5.78	5.15	5.87	6.20	6.44	6.52	6.70	6.52	6.63
47-	-1.00	-1.00	-1.00	6.14	6.19	6.77	6.85	6.94	8.09	8.23
46-	-1.00	-1.00	-1.00	-1.00	6.52	6.99	7.07	7.17	8.09	8.21
45-	-1.00	-1.00	-1.00	-1.00	7.12	7.35	7.43	7.48	8.09	8.22
44-	-1.00	-1.00	-1.00	-1.00	7.70	7.78	7.87	7.68	8.09	8.22
43-	-1.00	-1.00	-1.00	-1.00	8.98	9.07	7.88	7.98	8.10	-1.00
42-	-1.00	-1.00	-1.00	-1.00	-1.00	9.09	9.19	-1.00	-1.00	-1.00
41-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 37

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 3.237, 6.714 (dB)

LATITUDE (DEG.)	113	111	109	107	105	103	101	99	97	95
55	5.33	5.12	4.68	4.66	4.64	4.20	4.35	4.58	4.59	4.11
54	5.14	5.18	4.81	4.39	4.37	4.61	4.60	4.60	4.18	4.19
53	4.86	4.82	4.79	4.38	4.36	4.73	5.09	5.09	5.10	5.37
52	4.03	4.81	4.78	4.36	4.35	5.08	5.08	5.42	5.42	5.26
51	3.78	4.22	4.20	4.17	4.17	4.90	5.23	5.55	5.56	5.75
50	3.24	3.74	4.11	4.17	4.16	4.62	5.08	5.27	6.71	6.46
49	3.59	3.35	3.86	4.16	3.75	4.44	5.07	6.22	6.42	6.45
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 38

```
*****************************************************************************
*                 *  Satellite located at 100.0 deg long;  Freq: 44.0 GHz *
*  ATT. TABLE     *  Site diversity: N ; site separation dist. =  0.0 km  *
*                 *                      Baseline to path angle=  0.0 deg *
*****************  Percentage of year that values are exceeded: 0.500    *
*                  Attenuation extrema:  Min, Max =  2.104,  5.191 (dB) *
*                                                                       *
*****************************************************************************
```

LATITUDE (DEG.)	133	131	129	127	125	123	121	119	117	115
55	-1.00	-1.00	-1.00	2.62	2.39	2.65	3.42	3.77	3.50	4.52
54	-1.00	-1.00	-1.00	-1.00	2.26	4.10	3.26	3.53	4.55	5.19
53	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	3.09	3.74	4.53	5.17
52	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.17	3.73	3.46	4.31
51	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.17	2.14	3.67	3.27
50	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.13	2.11	3.63
49	-1.00	-1.00	-1.00	-1.00	-1.00	3.36	-1.00	2.15	2.10	2.95
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 39

ATT. TABLE	Satellite located at 100.0 deg long; Freq: 44.0 GHz Site diversity: N ; site seperation dist. = 0.0 km Baseline to path angle= 0.0 deg Percentage of year that values are exceeded: 0.500 Attenuation extrema: Min, Max = 1.423, 4.569 (dB)

LATITUDE (DEG.)	81	79	77	75	73	71	69	67	65	63
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
67	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
66	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
65	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
64	1.42	1.45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
63	1.81	1.71	1.74	1.48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
62	2.59	2.15	2.21	1.76	1.49	1.83	-1.00	-1.00	-1.00	-1.00
61	2.86	2.90	2.67	1.97	2.01	2.29	2.12	-1.00	-1.00	-1.00
60	3.34	3.13	2.65	2.46	2.48	3.42	3.17	2.15	-1.00	-1.00
59	3.31	3.52	3.02	2.67	3.32	3.39	3.55	3.50	3.60	-1.00
58	3.44	4.00	3.77	3.53	3.41	3.77	3.89	3.84	3.95	-1.00
57	3.91	3.68	3.96	3.72	3.89	4.09	4.18	4.29	4.25	4.38
56	3.93	3.98	4.16	4.03	4.38	4.26	4.35	4.46	4.43	4.56

LONGITUDE (DEG.)

Table 40

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 1.037, 4.272 (dB)

LATITUDE (DEG.)	101	99	97	95	93	91	89	87	85	83
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	1.07	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	1.27	1.04	1.27	1.04	1.05	1.05	-1.00	-1.00	-1.00	-1.00
67	1.37	1.37	1.37	1.13	1.14	1.14	-1.00	-1.00	-1.00	-1.00
66	1.73	1.51	1.52	1.26	1.53	1.27	-1.00	-1.00	-1.00	-1.00
65	1.84	1.84	1.85	1.63	1.63	1.64	1.38	1.39	-1.00	-1.00
64	1.91	1.91	2.15	2.04	2.05	2.06	1.76	1.37	1.39	1.40
63	2.23	2.02	2.45	2.46	2.47	2.48	2.15	2.52	2.19	2.22
62	2.45	2.23	2.70	2.43	2.67	2.68	2.70	2.73	2.38	2.19
61	2.18	2.42	2.68	2.63	2.93	2.95	2.67	2.70	2.73	2.76
60	2.35	2.26	2.89	2.89	2.91	2.92	2.94	2.97	2.70	3.04
59	2.62	2.49	2.87	2.87	3.13	3.14	3.17	3.19	3.23	3.26
58	2.61	2.61	2.61	3.71	2.87	2.88	2.90	3.17	3.20	3.66
57	3.92	3.92	3.55	2.60	2.61	3.18	3.75	3.78	3.82	3.86
56	4.11	3.56	3.91	3.92	3.24	3.58	3.61	4.27	3.83	3.88

LONGITUDE (DEG.)

Table 41

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 1.274, 4.665 (dB)

LATITUDE (DEG.)	121	119	117	115	113	111	109	107	105	103
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	1.85	1.82	1.79	1.76	1.74	1.72	-1.00	1.52	-1.00	-1.00
68	1.96	2.11	2.08	2.05	1.86	1.84	1.82	1.48	1.48	1.27
67	2.33	2.29	2.26	2.23	2.02	2.00	1.99	1.88	1.68	1.67
66	2.46	2.59	2.55	2.52	2.33	2.12	2.10	2.09	1.88	1.88
65	2.71	2.66	2.63	2.59	2.29	2.37	2.17	2.16	2.15	1.85
64	3.01	2.96	2.92	2.88	2.53	2.67	2.32	2.13	2.12	2.11
63	3.12	3.08	3.03	2.85	2.82	2.79	2.62	2.43	2.24	2.23
62	3.05	3.00	2.96	2.79	2.93	2.74	2.74	2.57	2.40	2.45
61	3.14	2.79	2.81	2.78	2.75	2.73	2.69	2.54	2.53	2.37
60	3.15	3.10	2.95	3.31	3.28	2.70	2.68	2.67	2.77	2.50
59	3.19	3.23	3.10	3.41	3.37	3.01	3.11	3.28	2.64	2.63
58	3.14	3.26	3.09	3.76	3.73	3.62	3.60	3.58	3.27	3.38
57	3.29	3.47	3.43	3.72	3.68	3.65	3.63	3.60	3.94	3.93
56	3.43	3.53	3.74	3.48	4.50	4.46	4.66	4.64	4.62	4.61

LONGITUDE (DEG.)

Table 42

```
ATT. TABLE   Satellite located at 100.0 deg long;  Freq: 44.0 GHz
             Site diversity: N ; site separation dist. =  0.0 km
                                 Baseline to path angle=  0.0 deg
             Percentage of year that values are exceeded: 0.500
             Attenuation extrema:  Min, Max =  1.883,  3.253 (dB)
```

LATITUDE (DEG.)	141	139	137	135	133	131	129	127	125	123
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	3.25	3.12	3.00	2.89	2.80	2.71	2.64	2.57	2.51	1.88
68	3.15	3.02	2.91	2.81	2.72	2.64	2.57	2.51	2.45	2.00
67	3.06	2.94	2.83	2.74	2.66	2.80	2.73	2.66	2.60	2.37
66	2.98	2.87	3.01	2.91	2.82	2.74	2.67	2.61	2.55	2.50
65	-1.00	2.81	2.95	2.85	2.77	2.89	2.81	2.75	2.69	2.64
64	-1.00	2.76	2.76	3.01	2.92	3.02	2.94	2.87	2.94	2.88
63	-1.00	2.71	2.71	2.63	3.05	3.14	3.06	2.99	3.05	2.99
62	-1.00	-1.00	2.85	2.76	2.99	3.25	3.17	3.10	3.03	2.98
61	-1.00	-1.00	3.13	3.03	2.95	2.87	3.13	3.06	3.00	3.07
60	-1.00	-1.00	-1.00	3.00	2.92	2.84	2.78	2.71	2.66	2.85
59	-1.00	-1.00	-1.00	-1.00	2.89	2.82	2.75	2.69	2.76	2.94
58	-1.00	-1.00	-1.00	-1.00	-1.00	2.79	2.73	2.67	2.74	3.02
57	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.71	2.77	2.62	3.10
56	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	2.76	2.61	2.85

LONGITUDE (DEG.)

Table 43

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 4.573, 24.716 (dB)

LATITUDE (DEG.)	73	71	69	67	65	63	61	59	57	55
55	9.12	9.91	10.14	10.39	10.46	9.97	10.28	-1.00	-1.00	-1.00
54	10.87	10.41	10.65	10.91	10.81	10.55	10.88	10.56	-1.00	-1.00
53	10.49	11.05	11.30	11.57	11.34	11.47	11.24	11.18	-1.00	-1.00
52	11.35	11.44	11.69	11.17	11.83	12.16	11.96	11.76	4.57	-1.00
51	11.50	10.67	10.91	12.09	11.42	12.11	12.48	12.50	9.44	-1.00
50	12.20	11.83	12.09	12.25	12.97	13.09	13.00	13.42	13.89	14.41
49	11.62	11.85	12.30	12.99	13.32	13.88	14.67	15.45	14.82	14.35
48	15.91	16.44	14.27	12.96	13.29	9.18	16.51	16.73	15.62	17.83
47	18.43	19.89	16.99	15.20	11.31	12.53	16.48	16.59	17.15	17.78
46	19.07	18.79	16.55	15.18	11.29	12.51	12.88	19.15	23.09	23.93
45	19.02	18.78	20.29	17.99	19.48	20.00	20.58	21.66	22.39	-1.00
44	-1.00	-1.00	20.28	21.82	23.40	24.02	24.72	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	21.82	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 44

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 7.855, 20.230 (dB)

LATITUDE (DEG.)	93	91	89	87	85	83	81	79	77	75
55	7.86	8.67	8.73	7.96	8.04	8.85	8.96	9.09	9.24	9.40
54	10.12	9.09	9.16	8.77	8.85	9.73	9.86	10.00	10.48	10.66
53	11.86	9.28	10.21	9.20	10.12	10.23	10.36	11.35	11.53	11.18
52	11.26	11.89	11.97	10.27	10.37	10.48	11.49	11.65	11.83	11.68
51	12.71	12.78	11.95	10.33	10.79	11.46	11.60	11.76	11.80	12.00
50	14.03	12.76	11.35	12.02	11.67	12.18	12.33	13.57	12.88	11.43
49	13.61	12.74	11.34	12.48	12.90	13.63	13.79	14.96	15.39	15.65
48	-1.00	12.73	11.33	12.92	13.64	14.18	14.35	14.75	14.36	14.60
47	-1.00	-1.00	-1.00	13.50	13.63	14.89	15.07	15.27	17.81	18.10
46	-1.00	-1.00	-1.00	-1.00	14.34	15.38	15.56	15.77	17.80	18.07
45	-1.00	-1.00	-1.00	-1.00	15.68	16.17	16.38	16.45	17.80	18.09
44	-1.00	-1.00	-1.00	-1.00	16.93	17.11	17.31	16.91	17.80	18.09
43	-1.00	-1.00	-1.00	-1.00	19.76	19.97	17.33	17.56	17.82	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	20.00	20.23	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 45

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 7.123, 14.776 (dB)

LATITUDE (DEG.)	113	111	109	107	105	103	101	99	97	95
55	11.74	11.27	10.30	10.25	10.21	9.23	9.57	10.08	10.09	9.04
54	11.31	11.22	10.58	9.66	9.62	10.14	10.12	10.12	9.20	9.22
53	10.70	10.62	10.54	9.63	9.59	10.42	11.20	11.20	11.21	11.81
52	8.86	10.59	10.51	9.60	9.56	11.18	11.17	11.92	11.94	11.58
51	8.32	9.30	9.23	9.18	9.18	10.78	11.51	12.21	12.23	12.66
50	7.12	8.24	9.05	9.17	9.16	10.18	11.18	11.59	14.78	14.21
49	7.89	7.37	8.50	9.16	8.25	9.77	11.16	13.68	14.13	14.19
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDE (DEG.)

Table 46

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 4.629, 11.424 (dB)

LATITUDE (DEG.)	133	131	129	127	125	123	121	119	117	115
55	-1.00	-1.00	-1.00	5.76	5.25	5.82	7.52	8.30	7.71	9.95
54	-1.00	-1.00	-1.00	-1.00	4.98	9.03	7.17	7.77	10.02	11.42
53	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	6.80	8.23	9.98	11.38
52	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	4.78	8.20	7.62	9.48
51	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	4.77	4.70	8.08	7.20
50	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	4.69	4.64	7.98
49	-1.00	-1.00	-1.00	-1.00	-1.00	7.40	-1.00	4.73	4.63	6.49
48	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
47	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
44	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
43	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
42	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 47

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 3.132, 10.033 (dB)

LATITUDE (DEG.)	81	79	77	75	73	71	69	67	65	63
70-	-1.00	-1.00	-1.00	-1.00	-1.60	-1.00	-1.00	-1.00	-1.00	-1.00
69-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
67-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
66-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
65-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
64-	3.13	3.18	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
63-	3.99	3.77	3.84	3.26	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
62-	5.70	4.74	4.87	3.87	3.28	4.04	-1.00	-1.00	-1.00	-1.00
61-	6.29	6.38	5.89	4.33	4.42	5.03	4.66	-1.00	-1.00	-1.00
60-	7.34	6.88	5.83	5.42	5.46	7.53	6.98	4.73	-1.00	-1.00
59-	7.28	7.74	6.64	5.89	7.30	7.46	7.81	7.71	7.92	-1.00
58-	7.57	8.80	8.29	7.77	7.51	8.29	8.55	8.45	8.69	-1.00
57-	8.61	8.10	8.72	8.18	8.56	9.00	9.21	9.44	9.36	9.64
56-	8.64	8.76	9.15	8.87	9.64	9.37	9.58	9.82	9.75	10.03

LONGITUDE (DEG.)

Table 48

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 2.282, 9.401 (dB)

LATITUDE (DEG.)	101	99	97	95	93	91	89	87	85	83
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	-1.00	-1.00	-1.00	2.34	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
68	2.80	2.28	2.80	2.29	2.30	2.32	-1.00	-1.00	-1.00	-1.00
67	3.02	3.02	3.02	2.49	2.50	2.52	-1.00	-1.00	-1.00	-1.00
66	3.81	3.33	3.34	2.77	3.36	2.80	-1.00	-1.00	-1.00	-1.00
65	4.06	4.06	4.06	3.58	3.59	3.62	3.03	3.06	-1.00	-1.00
64	4.20	4.20	4.72	4.48	4.50	4.53	3.86	3.02	3.05	3.09
63	4.91	4.46	5.39	5.41	5.43	5.46	4.72	5.66	4.82	4.88
62	5.39	4.91	5.95	5.35	5.87	5.90	5.94	6.00	5.23	4.82
61	4.81	5.33	5.89	5.78	6.45	6.49	5.89	5.94	6.00	6.07
60	5.17	4.97	6.35	6.37	6.39	6.43	6.48	6.53	5.95	6.68
59	5.78	5.47	6.30	6.32	6.88	6.92	6.97	7.03	7.10	7.18
58	5.74	5.74	5.75	8.16	6.31	6.34	6.39	6.98	7.05	8.06
57	8.63	8.63	7.82	5.73	5.75	6.99	8.25	8.32	8.40	8.50
56	9.05	7.83	8.60	8.62	7.14	7.88	7.93	9.40	8.43	8.53

LONGITUDE (DEG.)

Table 49

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 2.804, 10.265 (dB)

LATITUDE (DEG.)	121	119	117	115	113	111	109	107	105	103
70-	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69-	4.06	3.99	3.93	3.88	3.83	3.80	-1.00	3.34	-1.00	-1.00
68-	4.32	4.65	4.58	4.52	4.08	4.04	4.01	3.27	3.25	2.80
67-	5.13	5.04	4.97	4.90	4.45	4.41	4.37	4.13	3.69	3.68
66-	5.41	5.70	5.62	5.55	5.12	4.67	4.63	4.60	4.14	4.13
65-	5.96	5.86	5.78	5.71	5.04	5.22	4.78	4.75	4.73	4.06
64-	6.62	6.52	6.43	6.35	5.57	5.87	5.11	4.68	4.66	4.65
63-	6.88	6.77	6.68	6.27	6.20	6.15	5.76	5.36	4.93	4.91
62-	6.71	6.60	6.51	6.14	6.45	6.02	6.03	5.66	5.27	5.39
61-	6.92	6.13	6.19	6.12	6.05	6.00	5.92	5.59	5.56	5.21
60-	6.92	6.82	6.50	7.29	7.21	5.95	5.90	5.87	6.09	5.58
59-	7.02	7.12	6.82	7.50	7.42	6.62	6.84	7.21	5.80	5.78
58-	6.92	7.18	6.79	8.28	8.20	7.97	7.92	7.87	7.19	7.45
57-	7.24	7.64	7.55	8.18	8.10	8.03	7.98	7.93	8.67	8.65
56-	7.54	7.76	8.23	7.66	9.90	9.81	10.26	10.21	10.17	10.14

LONGITUDE (DEG.)

Table 50

ATT. TABLE

Satellite located at 100.0 deg long; Freq: 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 4.145, 7.159 (dB)

LATITUDE (DEG.)	141	139	137	135	133	131	129	127	125	123
70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
69	7.16	6.86	6.59	6.36	6.15	5.96	5.80	5.66	5.53	4.14
68	6.93	6.65	6.40	6.18	5.98	5.82	5.66	5.52	5.39	4.41
67	6.73	6.47	6.23	6.04	5.85	6.17	6.00	5.86	5.73	5.22
66	6.57	6.31	6.63	6.41	6.21	6.04	5.88	5.74	5.62	5.50
65	-1.00	6.19	6.49	6.28	6.09	6.35	6.19	6.05	5.92	5.80
64	-1.00	6.08	6.07	6.62	6.42	6.64	6.47	6.32	6.46	6.34
63	-1.00	5.97	5.97	5.79	6.72	6.90	6.73	6.58	6.72	6.59
62	-1.00	-1.00	6.27	6.08	6.57	7.14	6.97	6.81	6.67	6.55
61	-1.00	-1.00	6.89	6.68	6.49	6.32	6.89	6.74	6.60	6.76
60	-1.00	-1.00	-1.00	6.60	6.42	6.25	6.11	5.97	5.85	6.27
59	-1.00	-1.00	-1.00	-1.00	6.36	6.20	6.05	5.92	6.07	6.46
58	-1.00	-1.00	-1.00	-1.00	-1.00	6.14	6.00	5.87	6.03	6.64
57	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	5.96	6.10	5.55	6.82
56	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	6.06	5.74	6.26

LONGITUDE (DEG.)

Figs. 40-48 (pages 116-124)	**Rain attenuation exceedance ranges over a region, 40°N-70°N latitude and 55°W-145°W in longitude, in Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for the following values of P.** The legend gives the ranges of attenuation exceedance values corresponding to the symbols in the map. The longitude of the satellite is 100° W and there is no site diversity. The min. and max. attenuation exceedance values over the region are also shown.
Frequency	**Percentage P of time of an average year when the rain attenuation exceeds a range of values.**
20 GHz	(1) P = 0.5% ; (2) P = 0.1% ; (3) P = 0.01% .
30 GHz	(1) P = 1.0% ; (2) P = 0.5% ; (3) P = 0.1% .
44 GHz	(1) P = 1.0% ; (2) P = 0.5% ; (3) P = 0.1% .

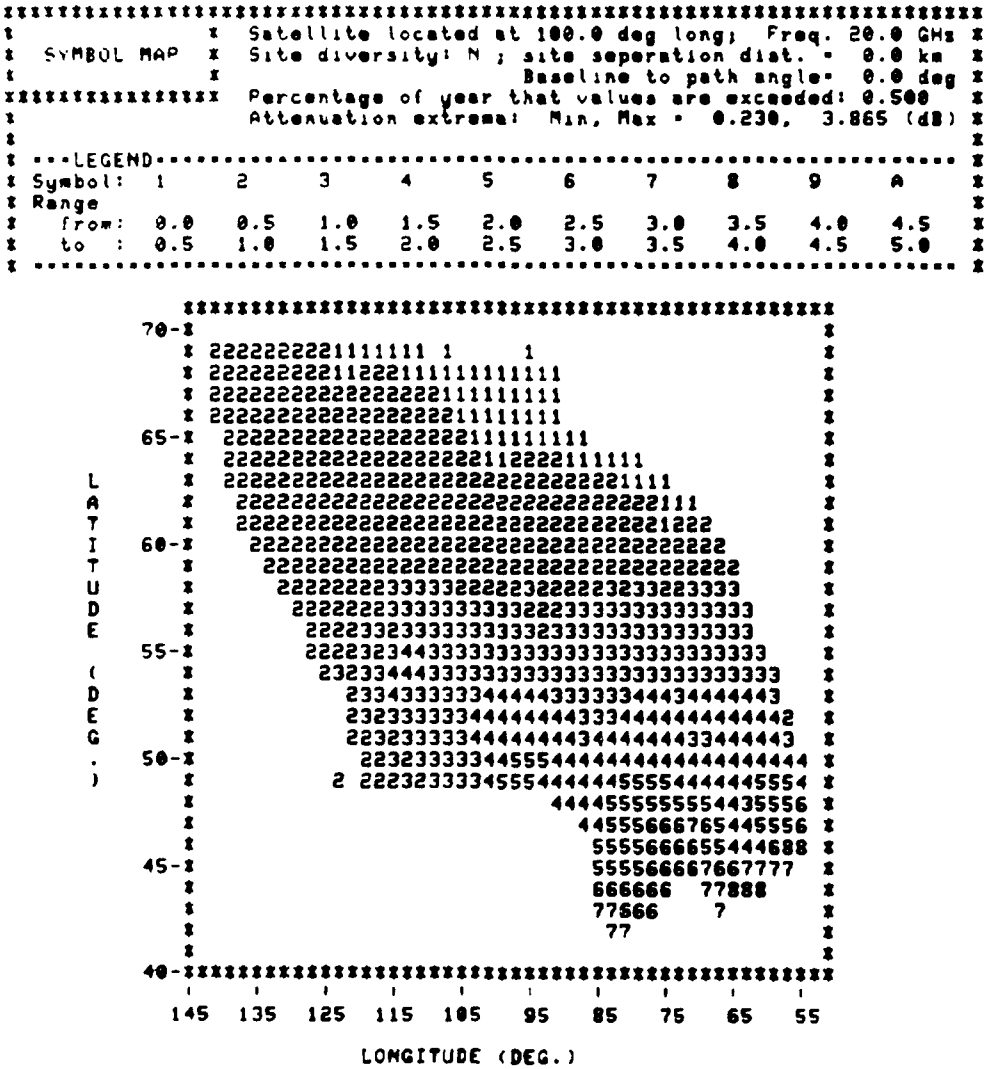

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 0.230, 3.865 (dB)
LEGEND
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
to : 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
70-
65-
60-
55-
50-
45-
40-
LATITUDE (DEG.)
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 40

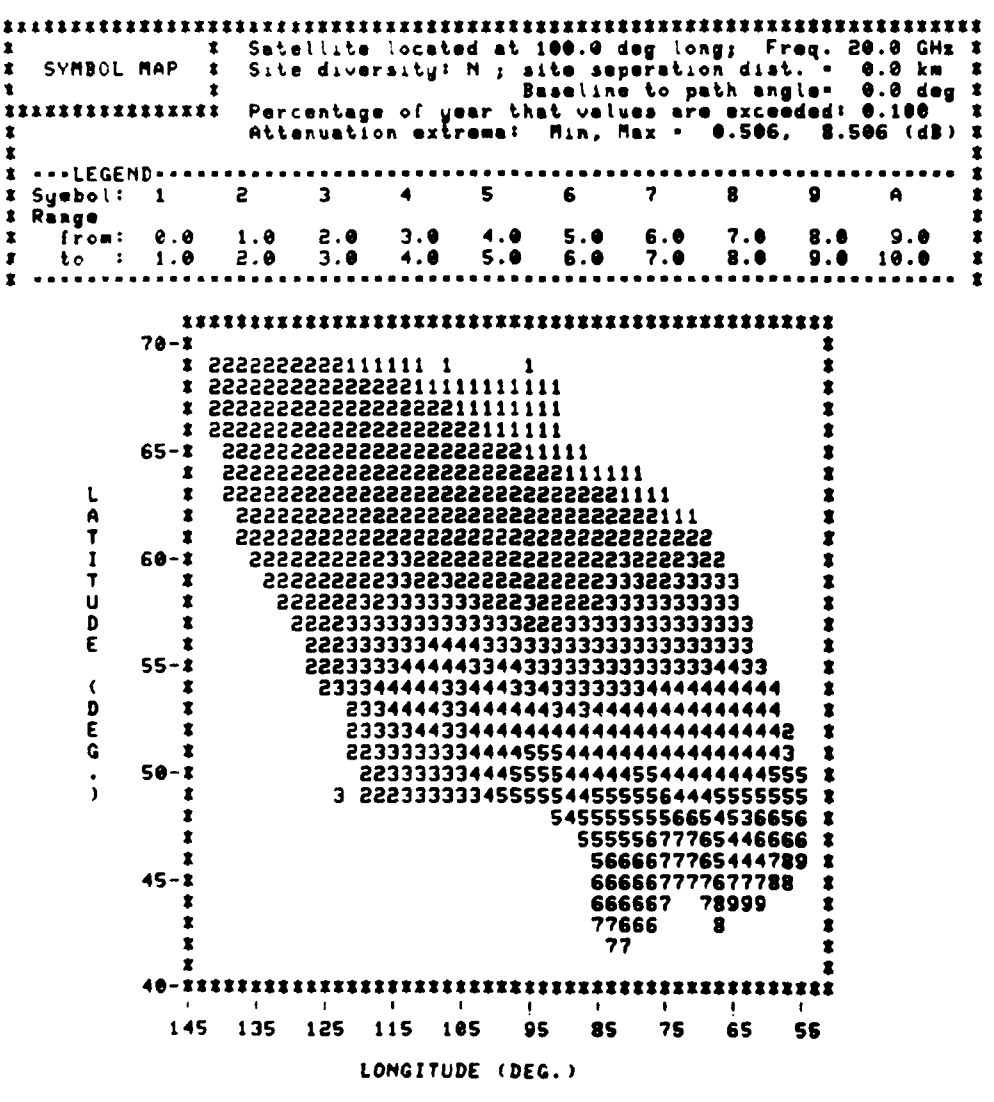

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 20.0 GHz
Site diversity: N ; site separation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 0.506, 8.506 (dB)
---LEGEND---
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
to : 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
70-
65-
60-
55-
50-
45-
40-
LATITUDE (DEG.)
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 41

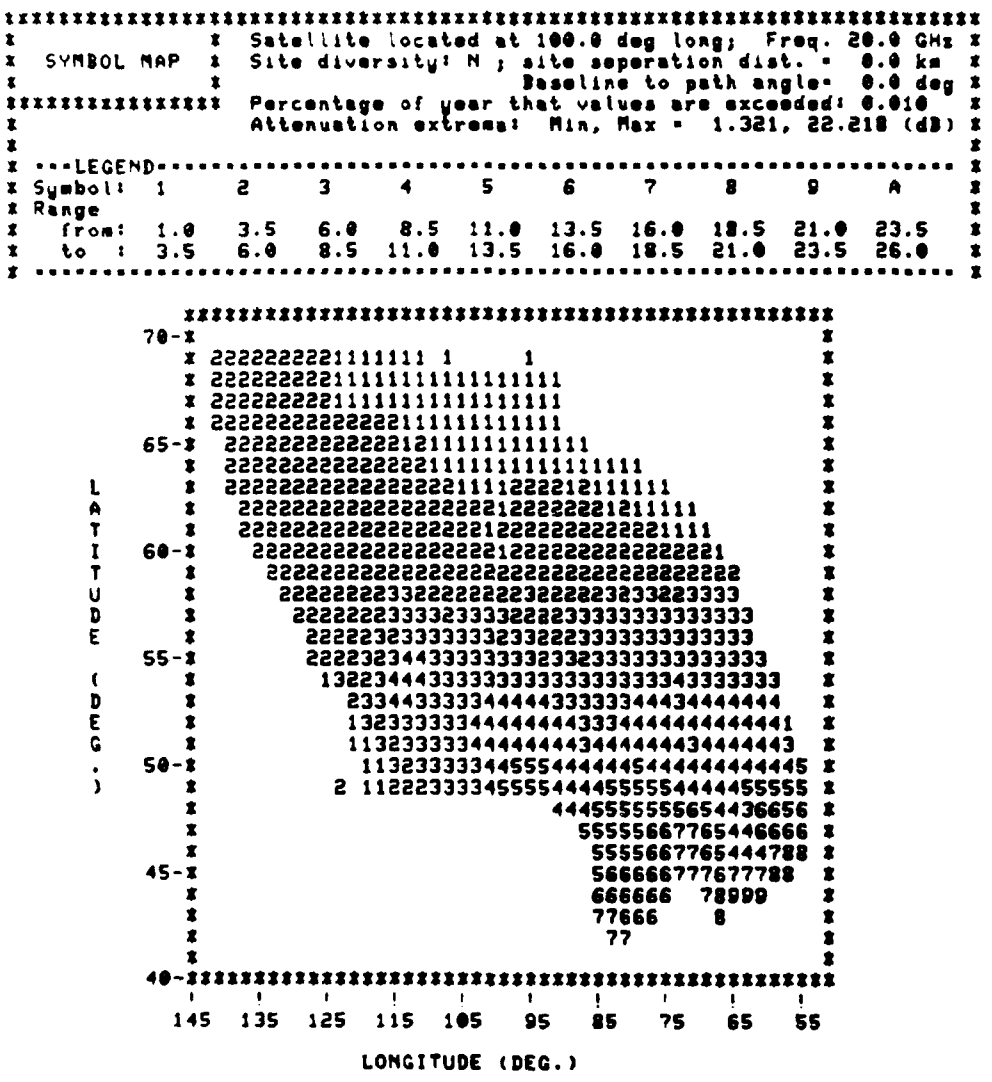

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 20.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.010
Attenuation extrems: Min, Max = 1.321, 22.218 (dB)
---LEGEND---
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 1.0 3.5 6.0 8.5 11.0 13.5 16.0 18.5 21.0 23.5
to : 3.5 6.0 8.5 11.0 13.5 16.0 18.5 21.0 23.5 26.0
70-
65-
60-
55-
50-
45-
40-
LATITUDE (DEG.)
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 42

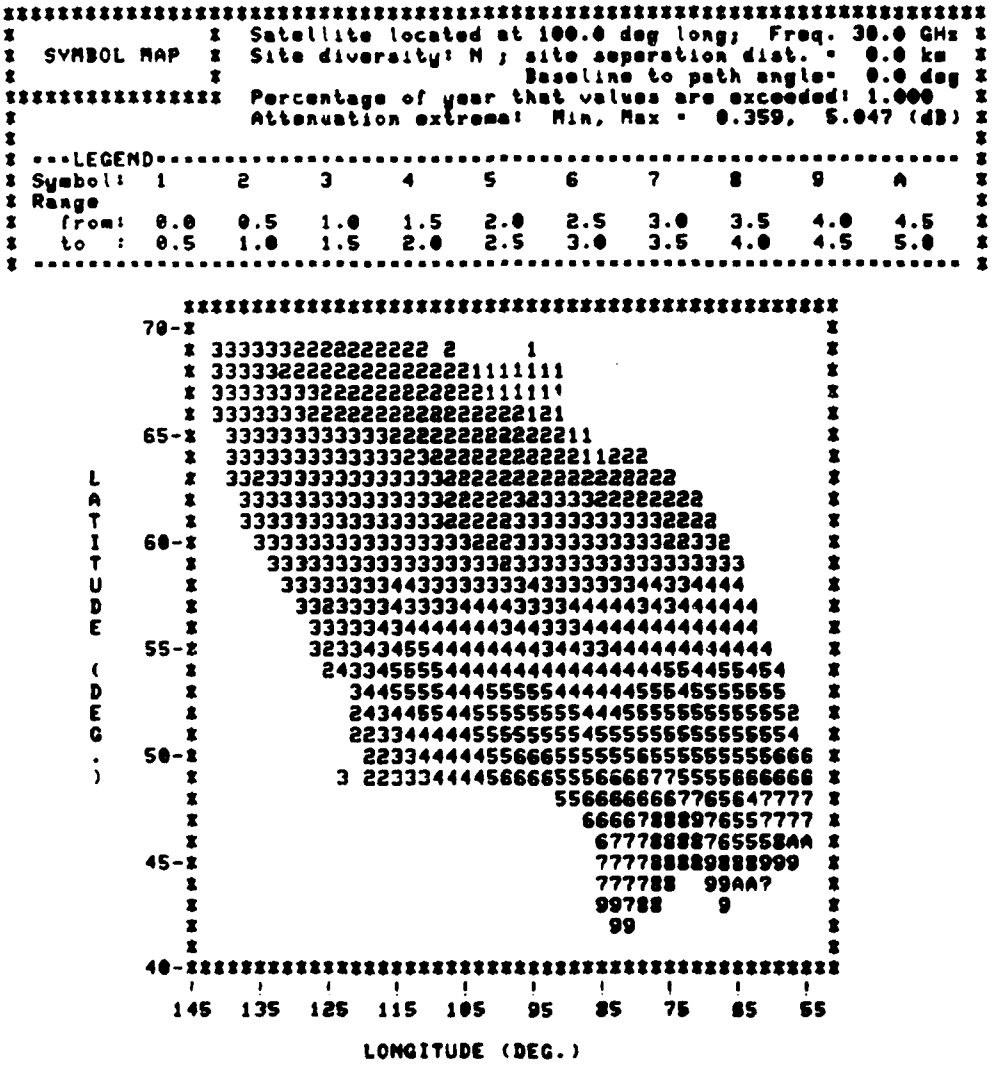

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 1.000
Attenuation extrema: Min, Max = 0.359, 5.047 (dB)
LEGEND
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
to : 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
70-
65-
60-
55-
50-
45-
40-
LATITUDE (DEG.)
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 43

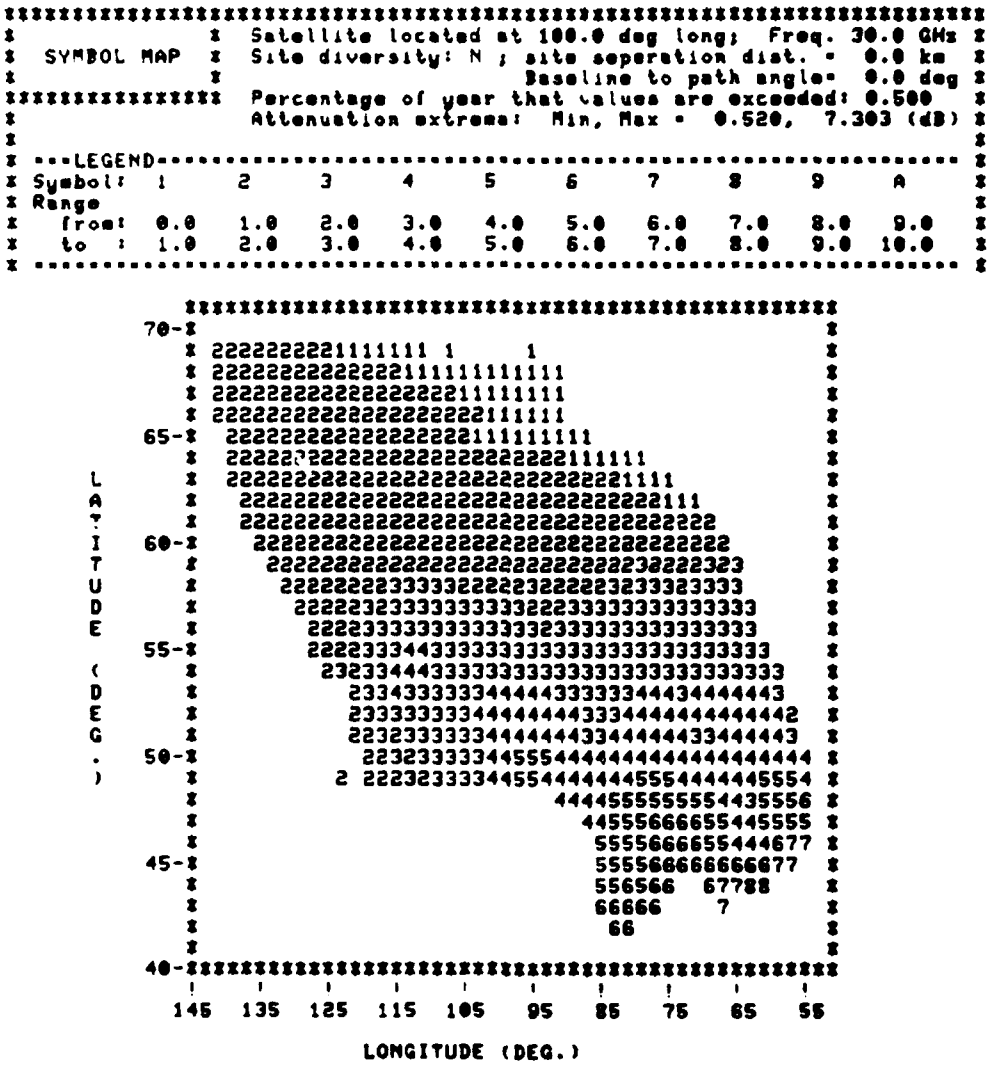

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extreme: Min, Max = 0.520, 7.303 (dB)
LEGEND
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
to : 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
LATITUDE (DEG.)
70-
65-
60-
55-
50-
45-
40-
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 44

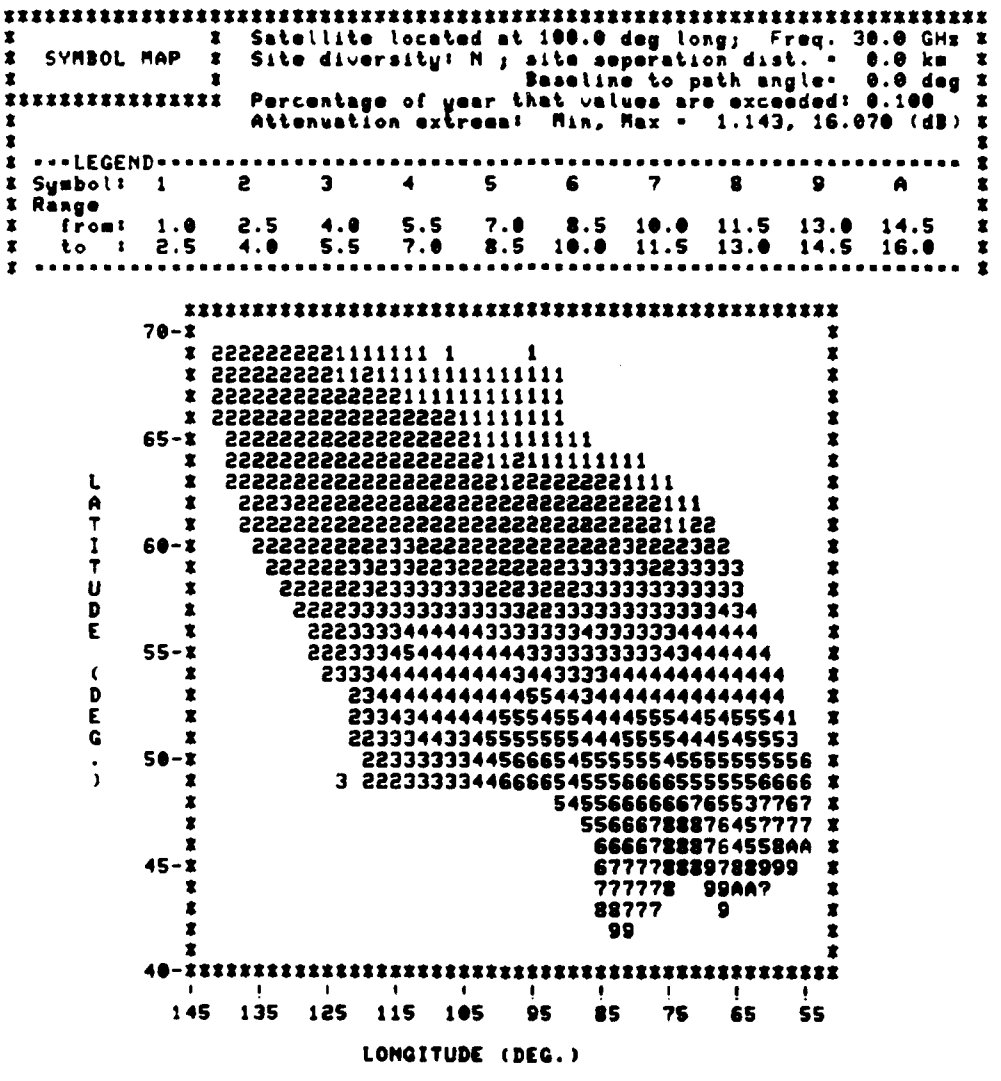

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 30.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 1.143, 16.070 (dB)
...LEGEND...
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 1.0 2.5 4.0 5.5 7.0 8.5 10.0 11.5 13.0 14.5
to : 2.5 4.0 5.5 7.0 8.5 10.0 11.5 13.0 14.5 16.0
70-
65-
60-
55-
50-
45-
40-
LATITUDE (DEG.)
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 45

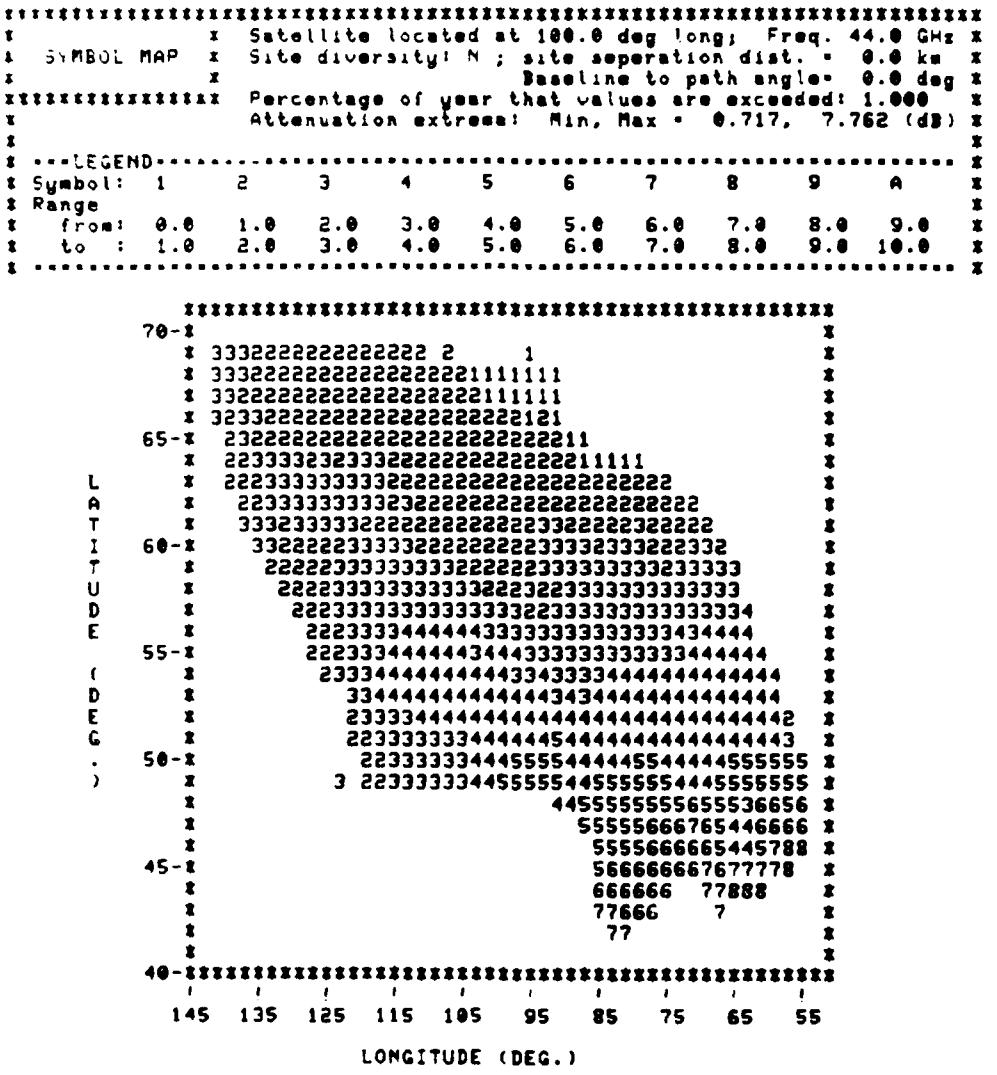

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 1.000
Attenuation extrema: Min, Max = 0.717, 7.762 (dB)
LEGEND
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
to : 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
70-
65-
60-
55-
50-
45-
40-
LATITUDE (DEG.)
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 46

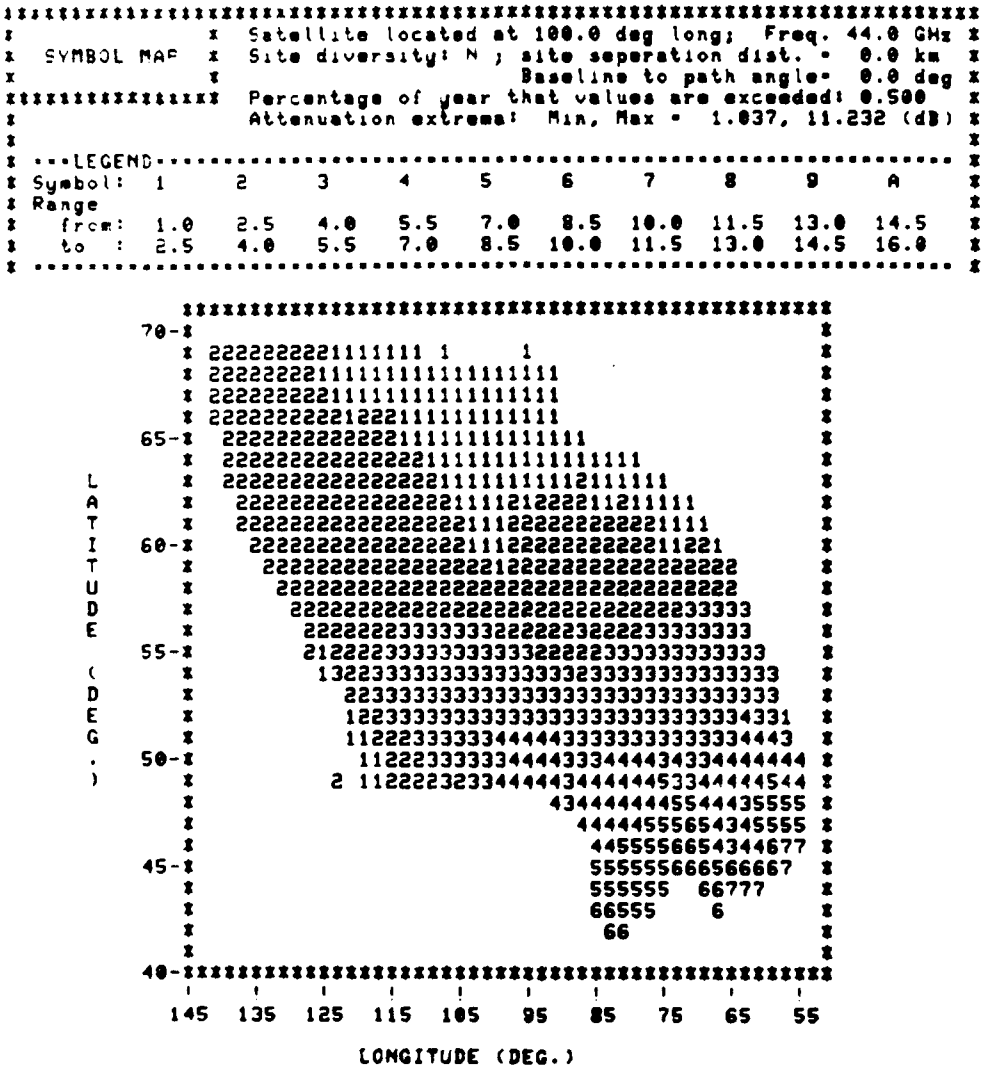

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.500
Attenuation extrema: Min, Max = 1.037, 11.232 (dB)
...LEGEND...
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 1.0 2.5 4.0 5.5 7.0 8.5 10.0 11.5 13.0 14.5
to : 2.5 4.0 5.5 7.0 8.5 10.0 11.5 13.0 14.5 16.0
70-
65-
60-
55-
50-
45-
40-
LATITUDE (DEG.)
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 47

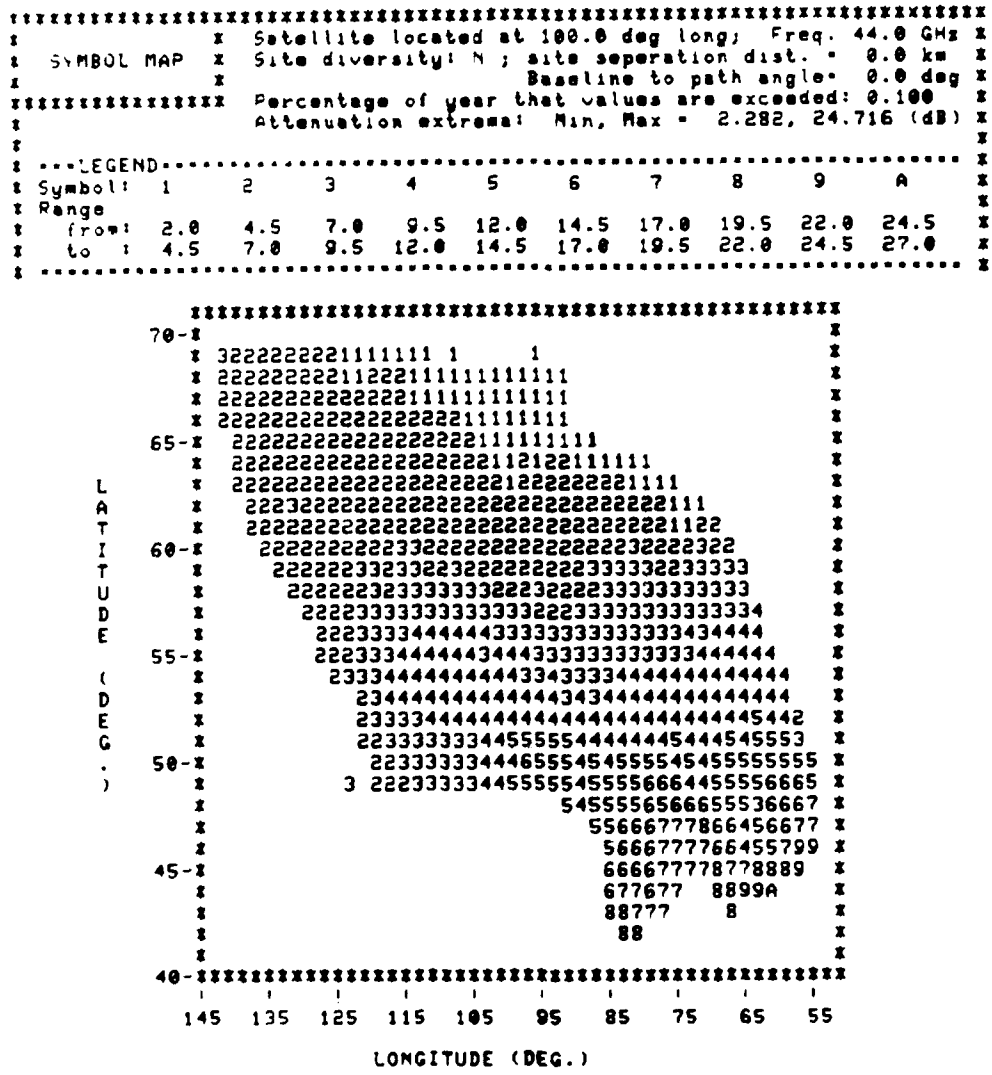

SYMBOL MAP
Satellite located at 100.0 deg long; Freq. 44.0 GHz
Site diversity: N ; site seperation dist. = 0.0 km
Baseline to path angle= 0.0 deg
Percentage of year that values are exceeded: 0.100
Attenuation extrema: Min, Max = 2.282, 24.716 (dB)
---LEGEND---
Symbol: 1 2 3 4 5 6 7 8 9 A
Range
from: 2.0 4.5 7.0 9.5 12.0 14.5 17.0 19.5 22.0 24.5
to : 4.5 7.0 9.5 12.0 14.5 17.0 19.5 22.0 24.5 27.0
LATITUDE (DEG.)
70-
65-
60-
55-
50-
45-
40-
145 135 125 115 105 95 85 75 65 55
LONGITUDE (DEG.)

Fig. 48

Figs. 49-63
(pages 126-140)

Rain attenuation exceedance values for selected sites in different regions of Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for P = 0.1%.

The longitude of the satellite is 100° W and there is no site diversity. The approximate position of the site is shown on a coarse map.

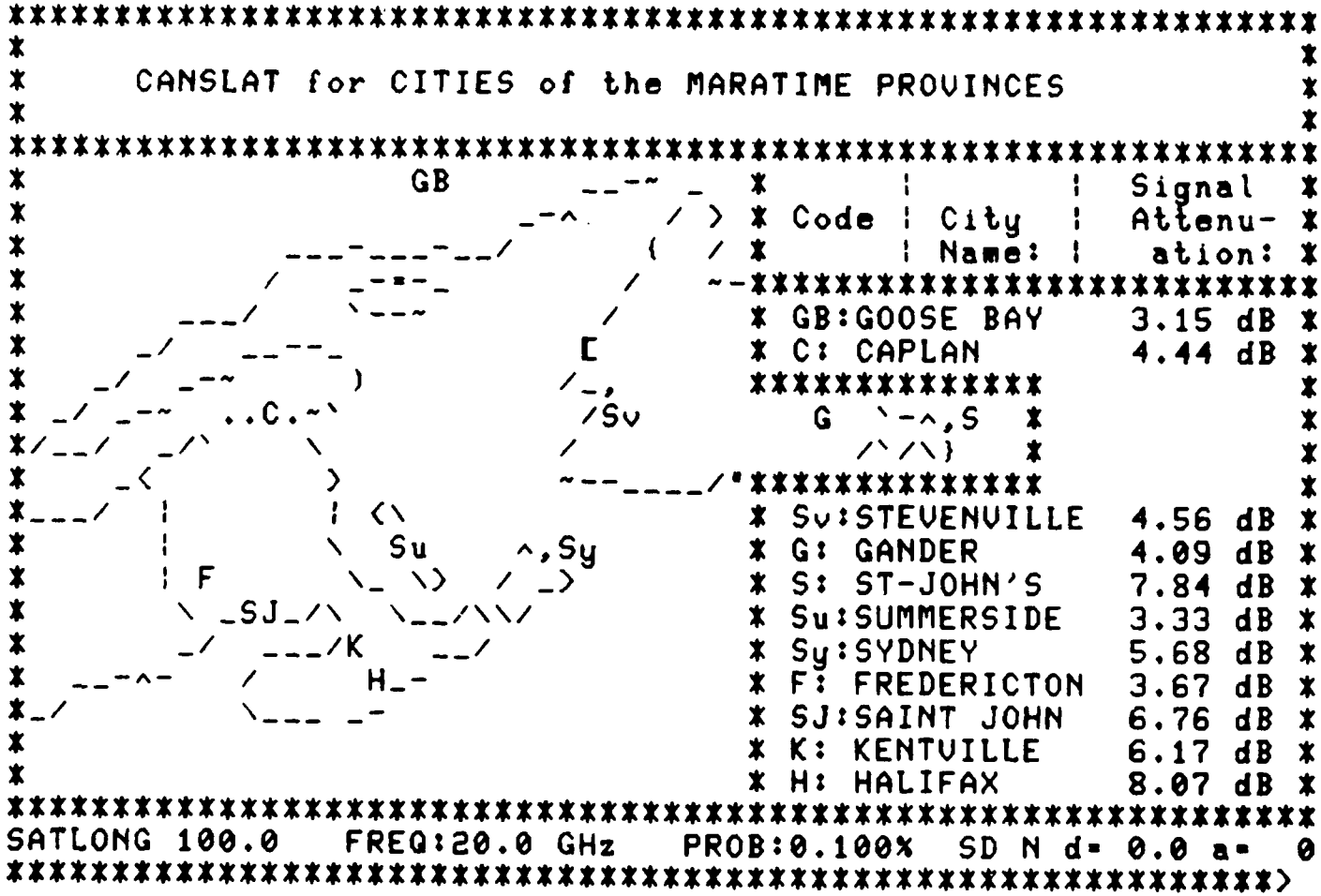

CANSLAT for CITIES of the MARATIME PROVINCES
GB
Sv
Su
Sy
F
SJ
K
H
Code | City Name: | Signal Attenu- ation:
GB:GOOSE BAY 3.15 dB
C: CAPLAN 4.44 dB
Sv:STEVENVILLE 4.56 dB
G: GANDER 4.09 dB
S: ST-JOHN'S 7.84 dB
Su:SUMMERSIDE 3.33 dB
Sy:SYDNEY 5.68 dB
F: FREDERICTON 3.67 dB
SJ:SAINT JOHN 6.76 dB
K: KENTVILLE 6.17 dB
H: HALIFAX 8.07 dB
SATLONG 100.0 FREQ:20.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 49

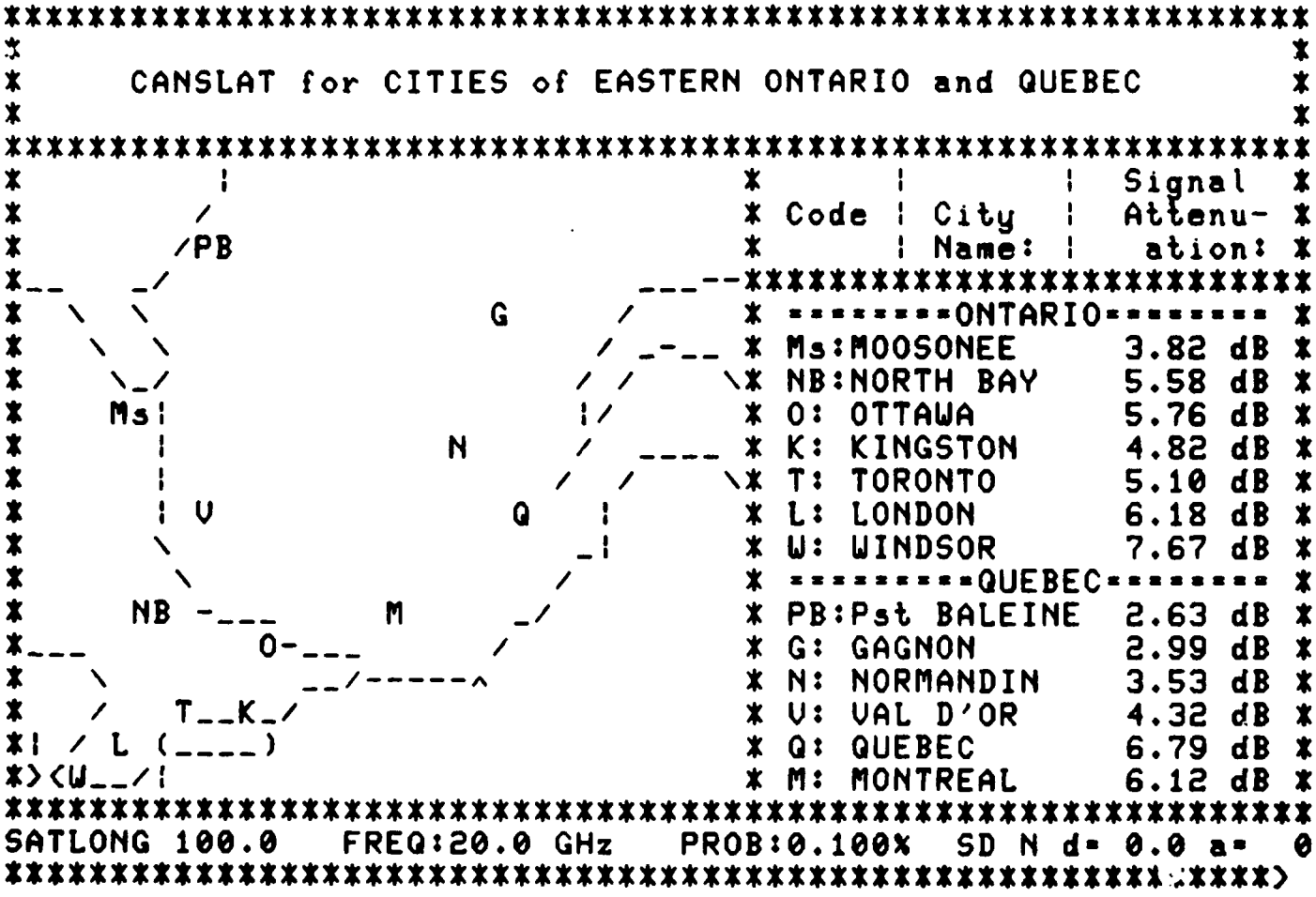

CANSLAT for CITIES of EASTERN ONTARIO and QUEBEC
Code | City Name: | Signal Attenu- ation:
ONTARIO
Ms:MOOSONEE 3.82 dB
NB:NORTH BAY 5.58 dB
O: OTTAWA 5.76 dB
K: KINGSTON 4.82 dB
T: TORONTO 5.10 dB
L: LONDON 6.18 dB
W: WINDSOR 7.67 dB
QUEBEC
PB:Pst BALEINE 2.63 dB
G: GAGNON 2.99 dB
N: NORMANDIN 3.53 dB
V: VAL D'OR 4.32 dB
Q: QUEBEC 6.79 dB
M: MONTREAL 6.12 dB
SATLONG 100.0 FREQ:20.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 50

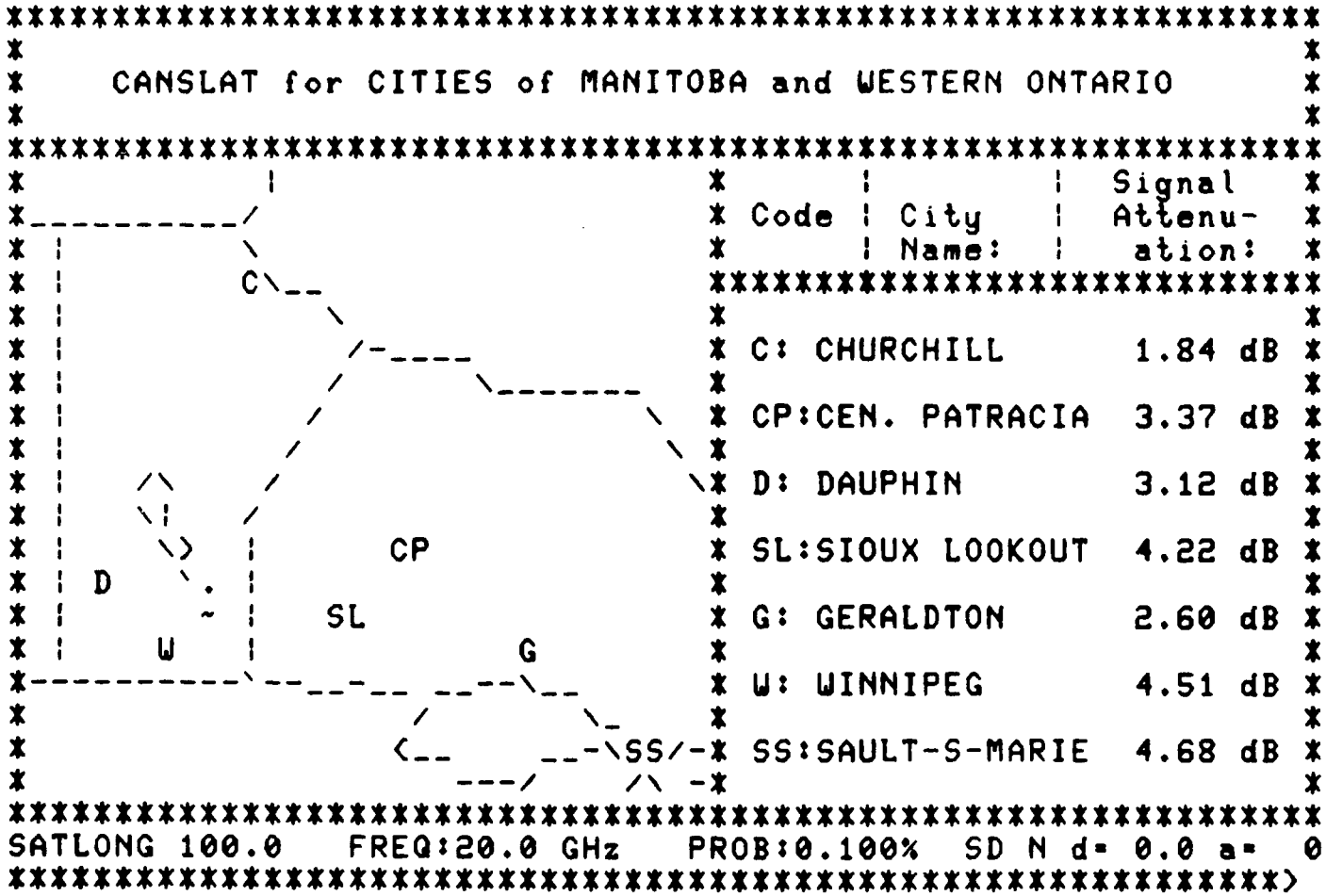

CANSLAT for CITIES of MANITOBA and WESTERN ONTARIO
Code | City Name: | Signal Attenu-ation:
C: CHURCHILL 1.84 dB
CP:CEN. PATRACIA 3.37 dB
D: DAUPHIN 3.12 dB
SL:SIOUX LOOKOUT 4.22 dB
G: GERALDTON 2.60 dB
W: WINNIPEG 4.51 dB
SS:SAULT-S-MARIE 4.68 dB
C
CP
D
SL
W
G
SS
SATLONG 100.0 FREQ:20.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 51

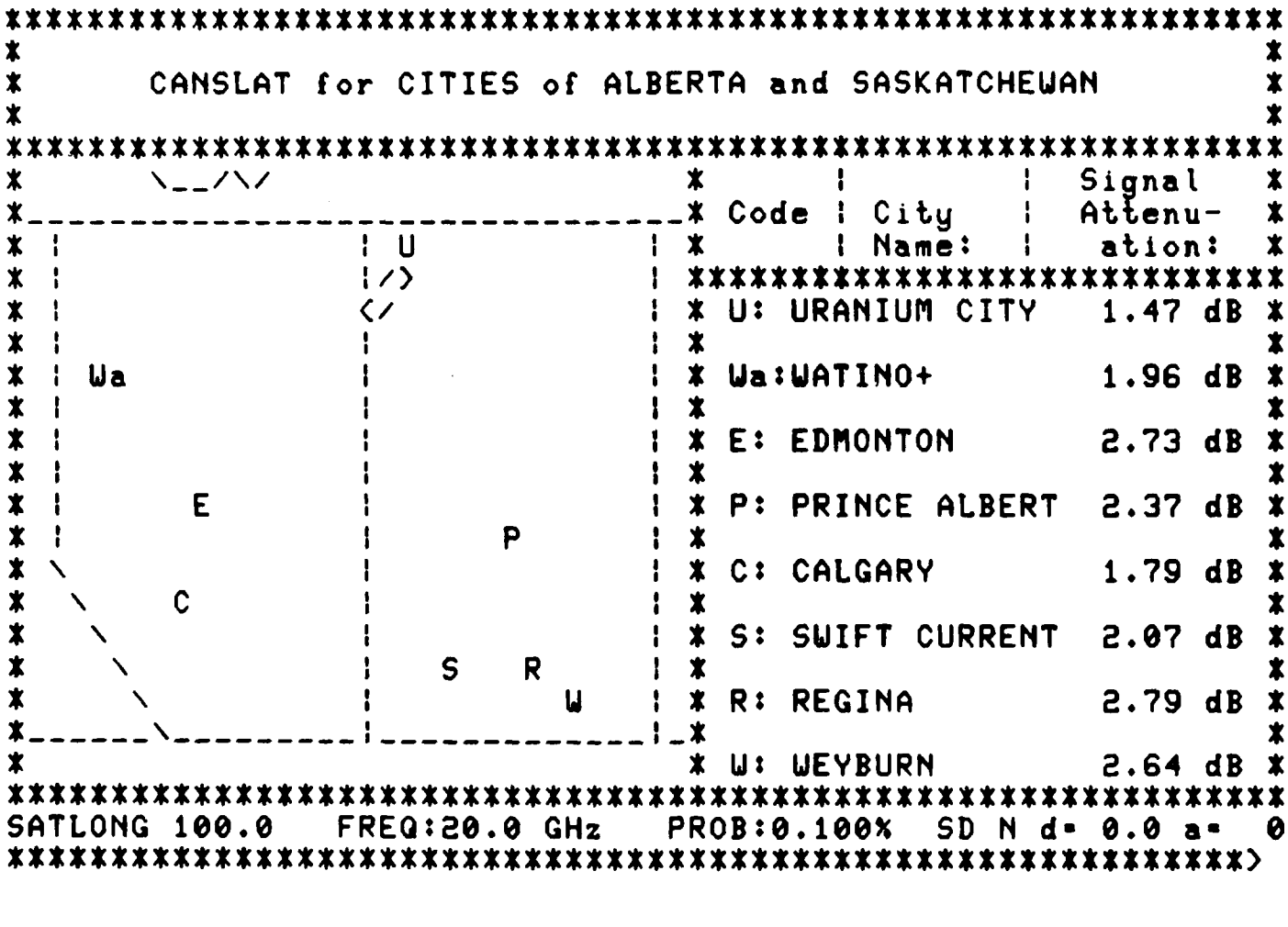

CANSLAT for CITIES of ALBERTA and SASKATCHEWAN
Code
City Name:
Signal Attenu-ation:
U: URANIUM CITY 1.47 dB
Wa:WATINO+ 1.96 dB
E: EDMONTON 2.73 dB
P: PRINCE ALBERT 2.37 dB
C: CALGARY 1.79 dB
S: SWIFT CURRENT 2.07 dB
R: REGINA 2.79 dB
W: WEYBURN 2.64 dB
U
Wa
E
P
C
S
R
W
SATLONG 100.0 FREQ:20.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 52

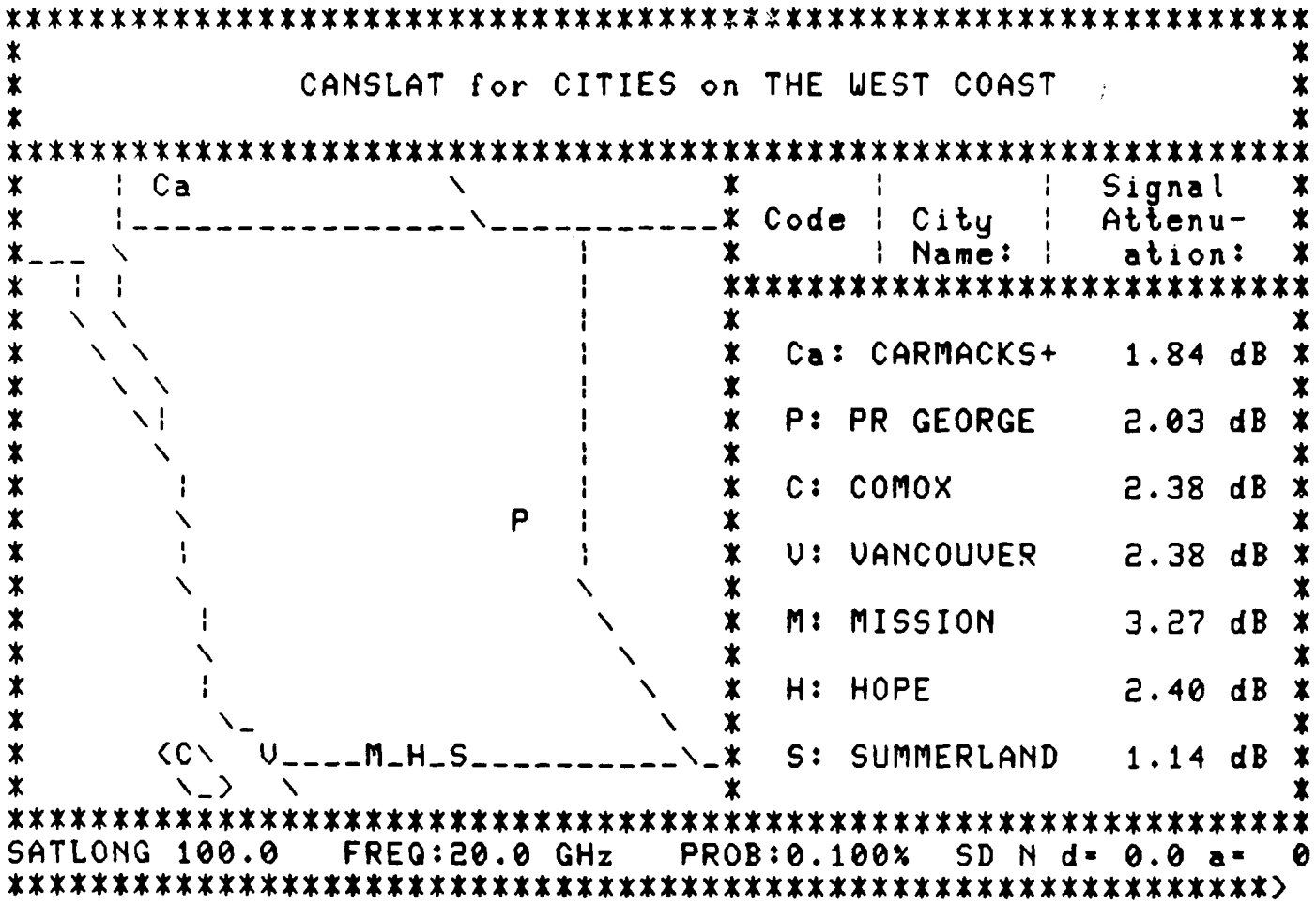

CANSLAT for CITIES on THE WEST COAST
Code
City Name:
Signal Attenu- ation:
Ca: CARMACKS+ 1.84 dB
P: PR GEORGE 2.03 dB
C: COMOX 2.38 dB
V: VANCOUVER 2.38 dB
M: MISSION 3.27 dB
H: HOPE 2.40 dB
S: SUMMERLAND 1.14 dB
Ca
P
C
V
M
H
S
SATLONG 100.0 FREQ:20.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 53

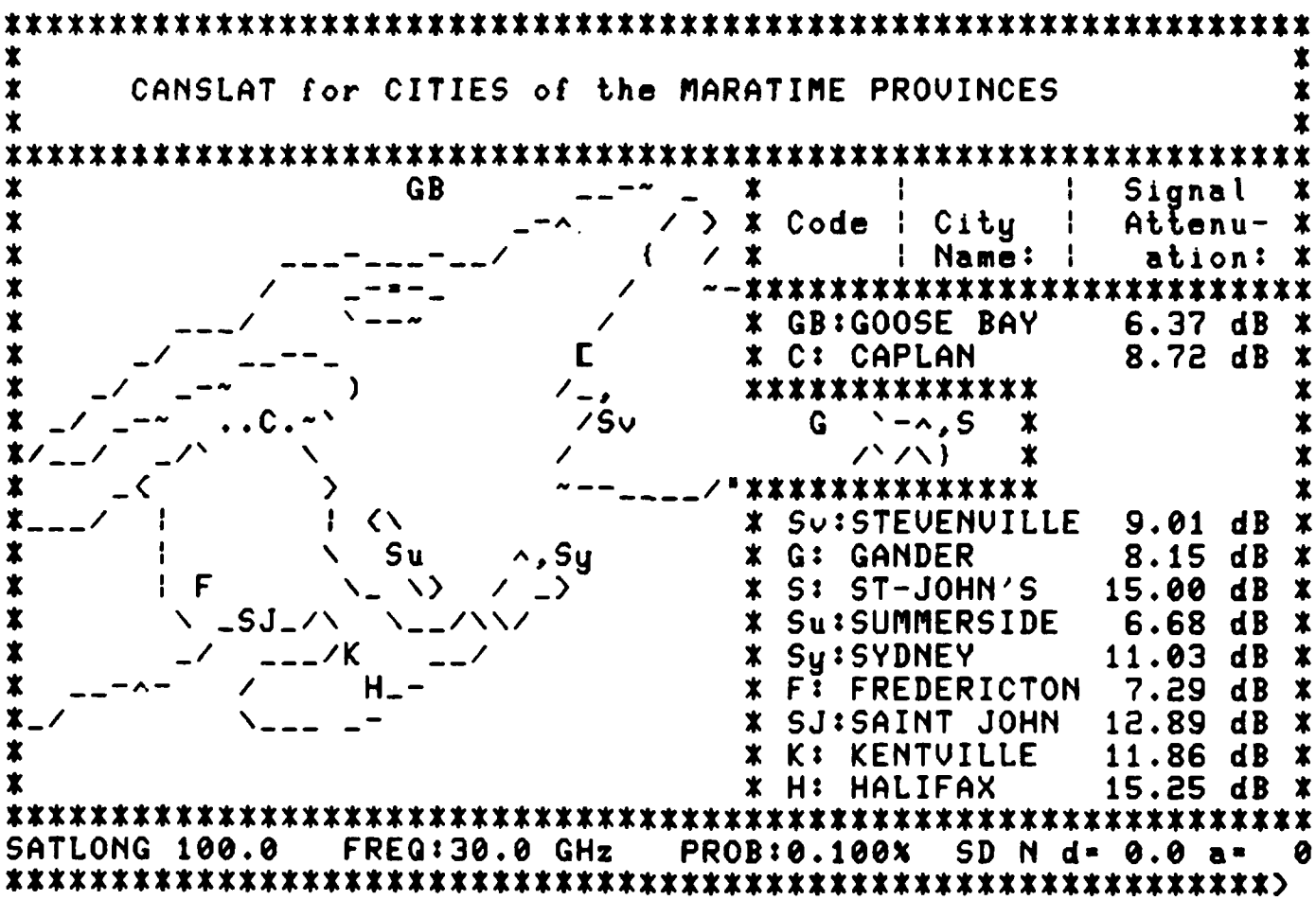

CANSLAT for CITIES of the MARATIME PROVINCES
Code | City Name: | Signal Attenu- ation:
GB:GOOSE BAY 6.37 dB
C: CAPLAN 8.72 dB
Sv:STEVENVILLE 9.01 dB
G: GANDER 8.15 dB
S: ST-JOHN'S 15.00 dB
Su:SUMMERSIDE 6.68 dB
Sy:SYDNEY 11.03 dB
F: FREDERICTON 7.29 dB
SJ:SAINT JOHN 12.89 dB
K: KENTVILLE 11.86 dB
H: HALIFAX 15.25 dB
SATLONG 100.0 FREQ:30.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 54

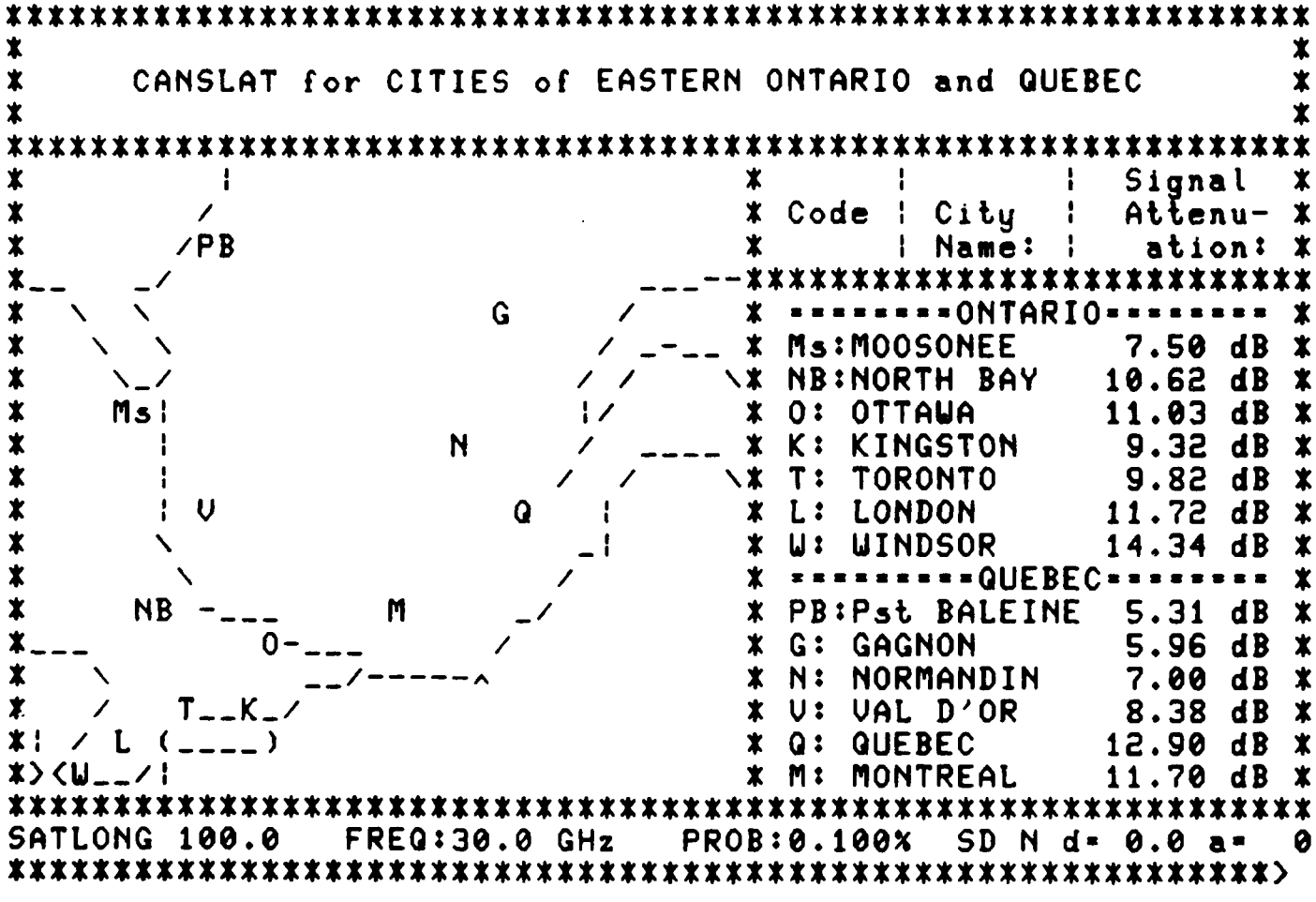

CANSLAT for CITIES of EASTERN ONTARIO and QUEBEC
Code | City Name: | Signal Attenu- ation:
--------ONTARIO--------
Ms:MOOSONEE 7.50 dB
NB:NORTH BAY 10.62 dB
O: OTTAWA 11.03 dB
K: KINGSTON 9.32 dB
T: TORONTO 9.82 dB
L: LONDON 11.72 dB
W: WINDSOR 14.34 dB
--------QUEBEC--------
PB:Pst BALEINE 5.31 dB
G: GAGNON 5.96 dB
N: NORMANDIN 7.00 dB
V: VAL D'OR 8.38 dB
Q: QUEBEC 12.90 dB
M: MONTREAL 11.70 dB
SATLONG 100.0 FREQ:30.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 55

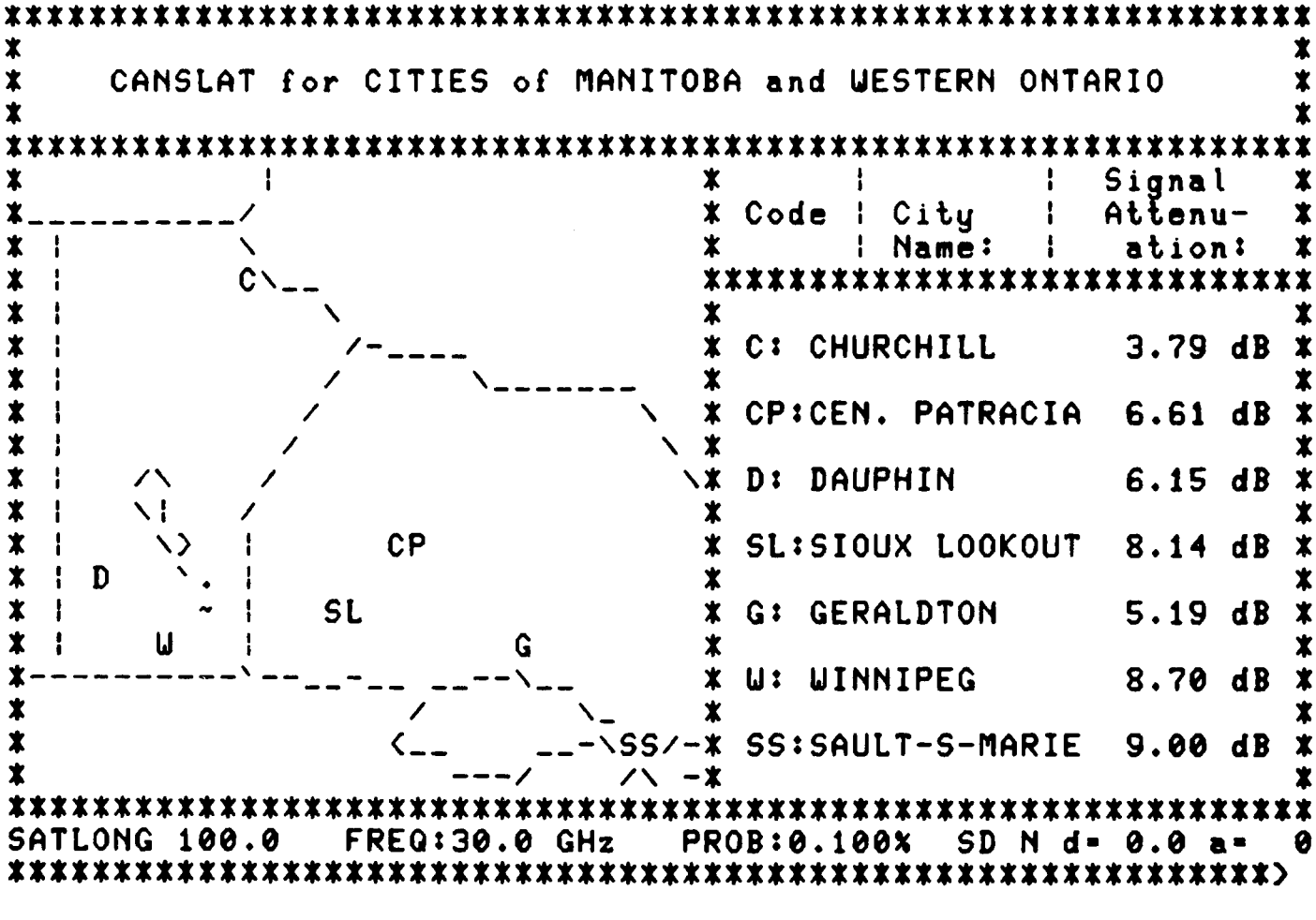

CANSLAT for CITIES of MANITOBA and WESTERN ONTARIO
Code | City Name: | Signal Attenu- ation:
C: CHURCHILL 3.79 dB
CP:CEN. PATRACIA 6.61 dB
D: DAUPHIN 6.15 dB
SL:SIOUX LOOKOUT 8.14 dB
G: GERALDTON 5.19 dB
W: WINNIPEG 8.70 dB
SS:SAULT-S-MARIE 9.00 dB
C
CP
D
SL
G
W
SS
SATLONG 100.0 FREQ:30.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 56

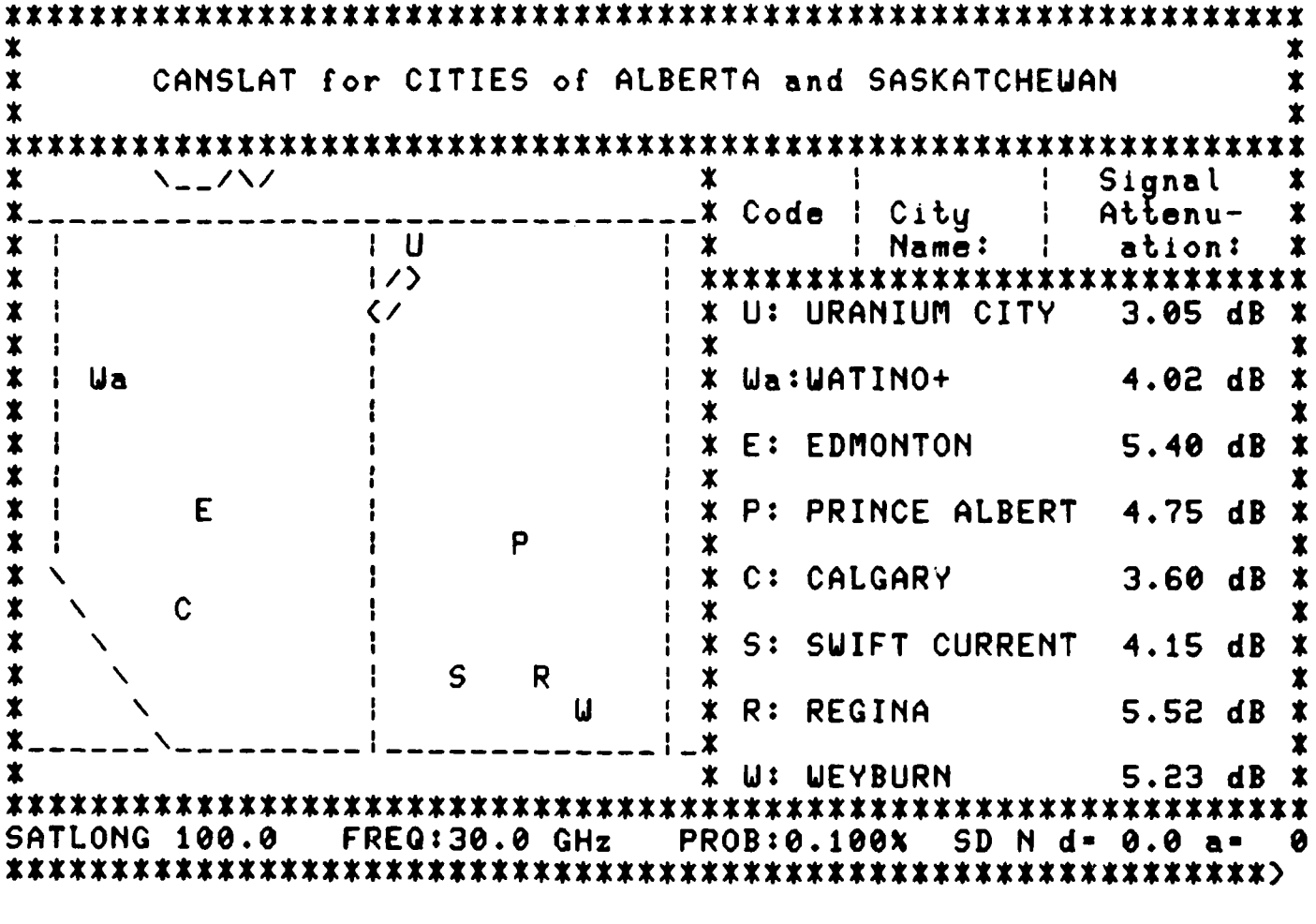

CANSLAT for CITIES of ALBERTA and SASKATCHEWAN
U
Wa
E
P
C
S
R
W
Code | City Name: | Signal Attenu- ation:
U: URANIUM CITY 3.05 dB
Wa:WATINO+ 4.02 dB
E: EDMONTON 5.40 dB
P: PRINCE ALBERT 4.75 dB
C: CALGARY 3.60 dB
S: SWIFT CURRENT 4.15 dB
R: REGINA 5.52 dB
W: WEYBURN 5.23 dB
SATLONG 100.0 FREQ:30.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 57

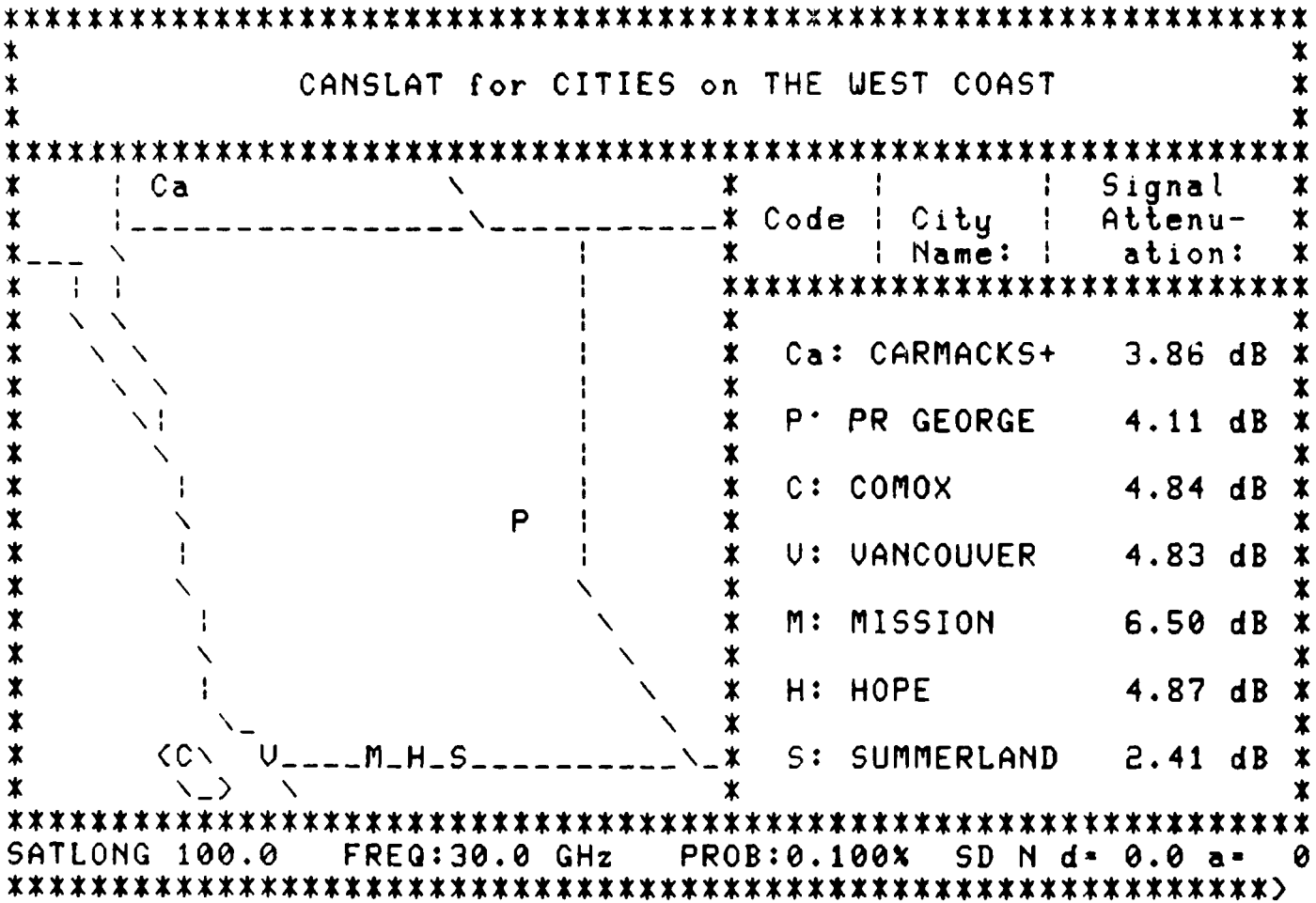
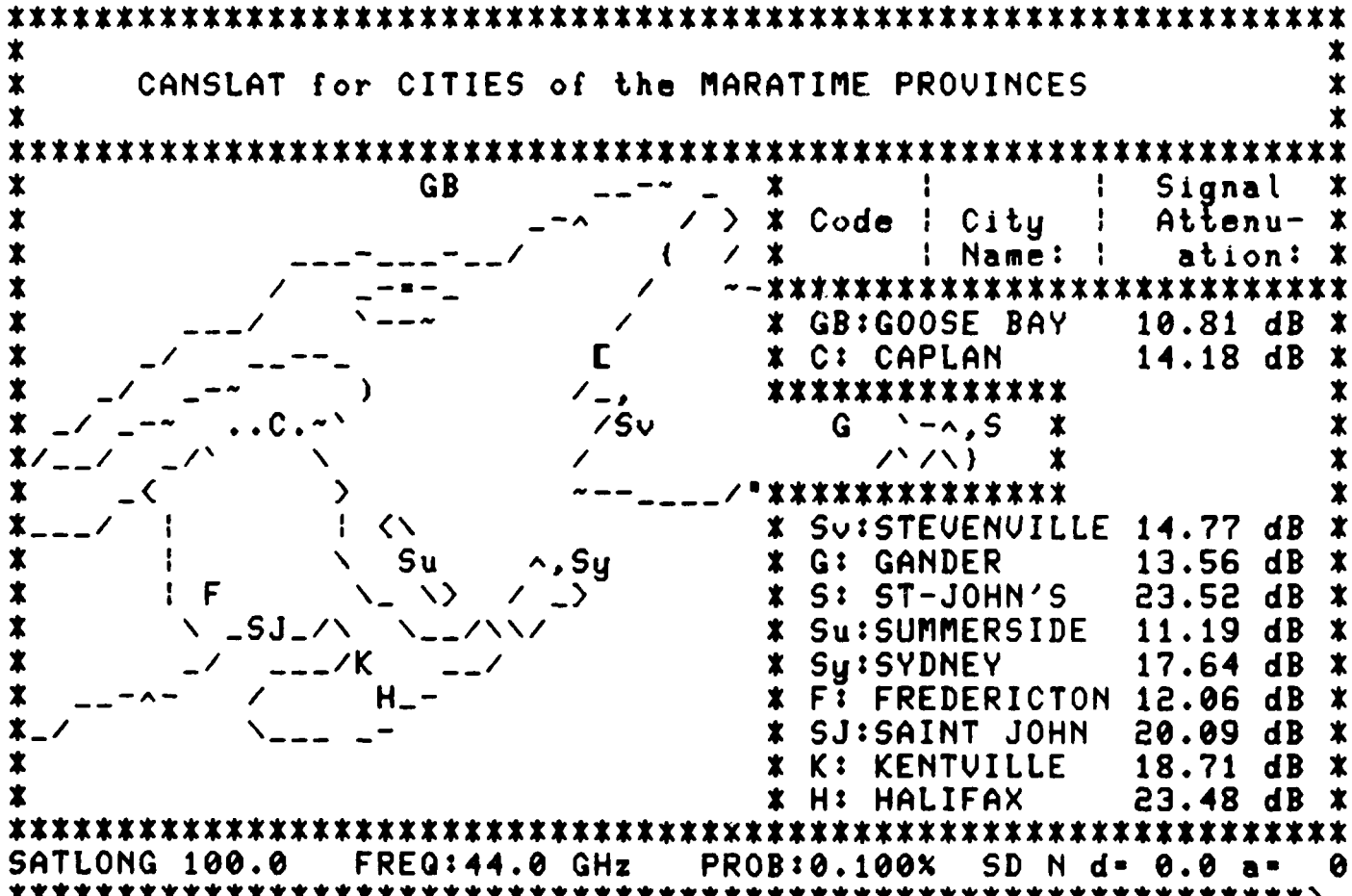

CANSLAT for CITIES on THE WEST COAST
Code
City Name:
Signal Attenu- ation:
Ca: CARMACKS+ 3.86 dB
P: PR GEORGE 4.11 dB
C: COMOX 4.84 dB
V: VANCOUVER 4.83 dB
M: MISSION 6.50 dB
H: HOPE 4.87 dB
S: SUMMERLAND 2.41 dB
Ca
P
C
V
M
H
S
SATLONG 100.0 FREQ:30.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 58


CANSLAT for CITIES of the MARATIME PROVINCES
GB
C
Sv
G
S
Su
Sy
F
SJ
K
H
Code | City Name: | Signal Attenu- ation:
GB:GOOSE BAY 10.81 dB
C: CAPLAN 14.18 dB
Sv:STEVENVILLE 14.77 dB
G: GANDER 13.56 dB
S: ST-JOHN'S 23.52 dB
Su:SUMMERSIDE 11.19 dB
Sy:SYDNEY 17.64 dB
F: FREDERICTON 12.06 dB
SJ:SAINT JOHN 20.09 dB
K: KENTVILLE 18.71 dB
H: HALIFAX 23.48 dB
SATLONG 100.0 FREQ:44.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fi· 59

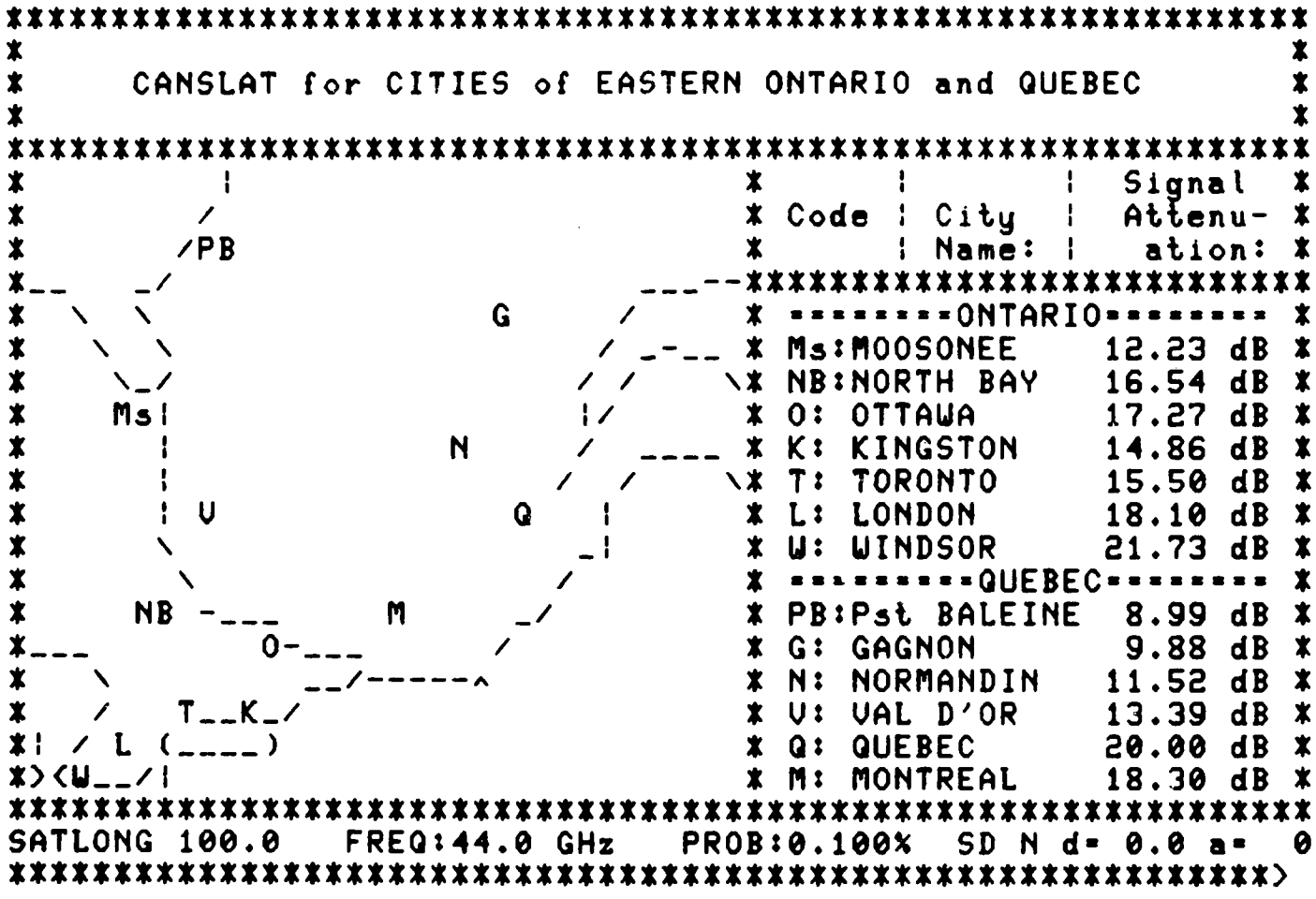

CANSLAT for CITIES of EASTERN ONTARIO and QUEBEC
Code | City Name: | Signal Attenu- ation:
ONTARIO
Ms: MOOSONEE 12.23 dB
NB: NORTH BAY 16.54 dB
O: OTTAWA 17.27 dB
K: KINGSTON 14.86 dB
T: TORONTO 15.50 dB
L: LONDON 18.10 dB
W: WINDSOR 21.73 dB
QUEBEC
PB: Pst BALEINE 8.99 dB
G: GAGNON 9.88 dB
N: NORMANDIN 11.52 dB
V: VAL D'OR 13.39 dB
Q: QUEBEC 20.00 dB
M: MONTREAL 18.30 dB
SATLONG 100.0 FREQ:44.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 60

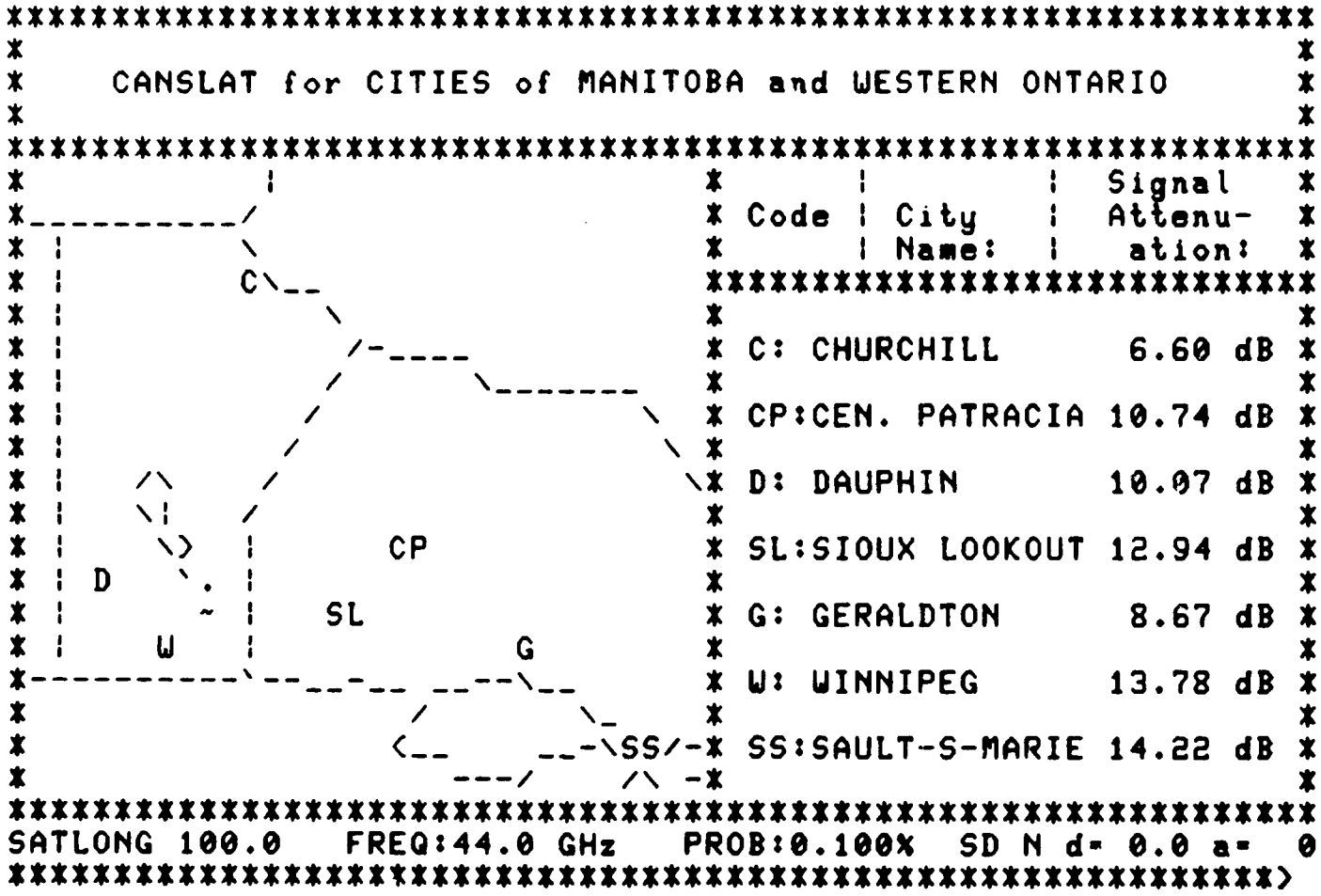

CANSLAT for CITIES of MANITOBA and WESTERN ONTARIO
Code | City Name: | Signal Attenu- ation:
C: CHURCHILL 6.60 dB
CP:CEN. PATRACIA 10.74 dB
D: DAUPHIN 10.07 dB
SL:SIOUX LOOKOUT 12.94 dB
G: GERALDTON 8.67 dB
W: WINNIPEG 13.78 dB
SS:SAULT-S-MARIE 14.22 dB
C
CP
D
SL
G
W
SS
SATLONG 100.0 FREQ:44.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 61

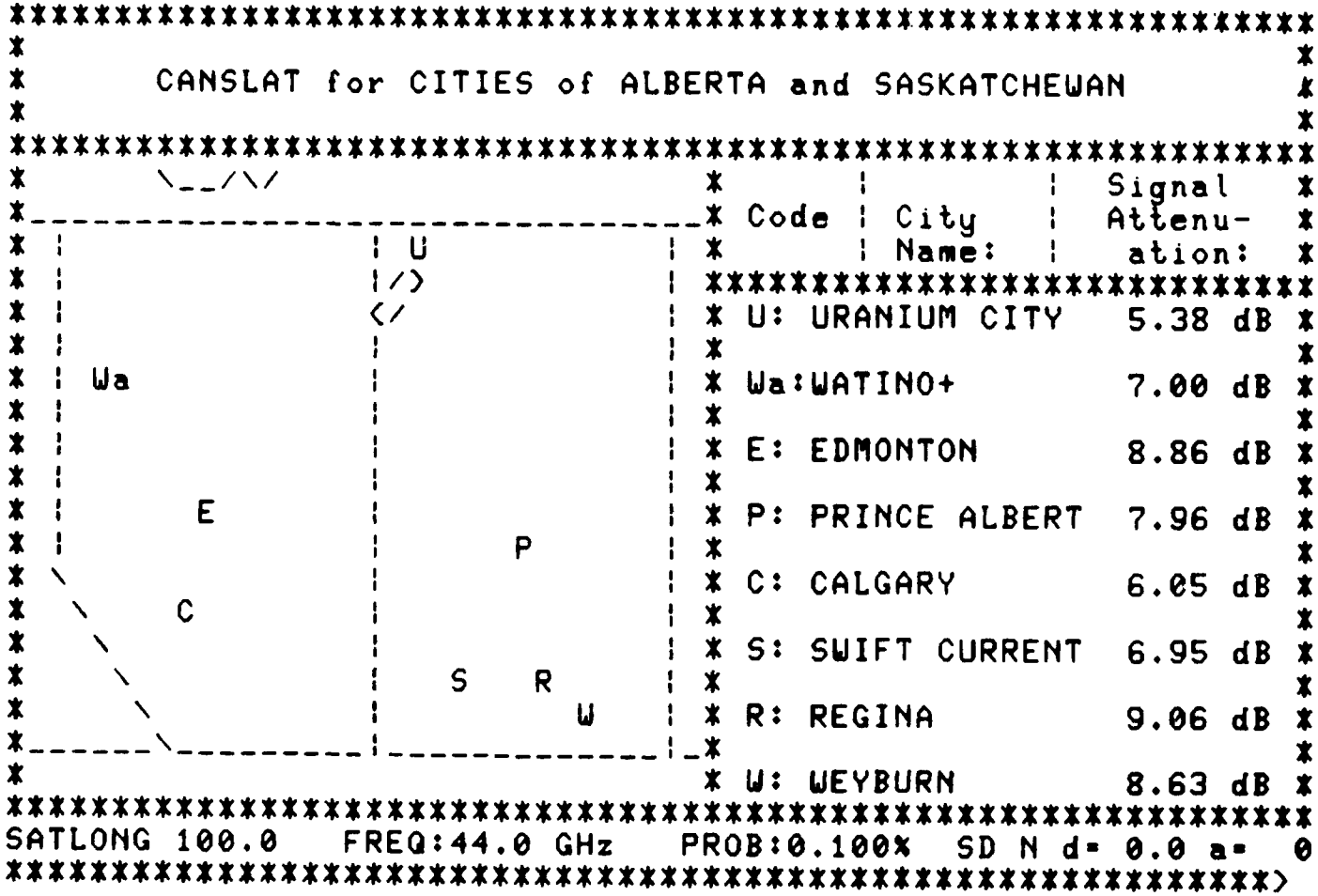

CANSLAT for CITIES of ALBERTA and SASKATCHEWAN
Code | City Name: | Signal Attenu- ation:
U: URANIUM CITY 5.38 dB
Wa:WATINO+ 7.00 dB
E: EDMONTON 8.86 dB
P: PRINCE ALBERT 7.96 dB
C: CALGARY 6.05 dB
S: SWIFT CURRENT 6.95 dB
R: REGINA 9.06 dB
W: WEYBURN 8.63 dB
SATLONG 100.0 FREQ:44.0 GHz PROB:0.100% SD N d= 0.0 a= 0

Fig. 62

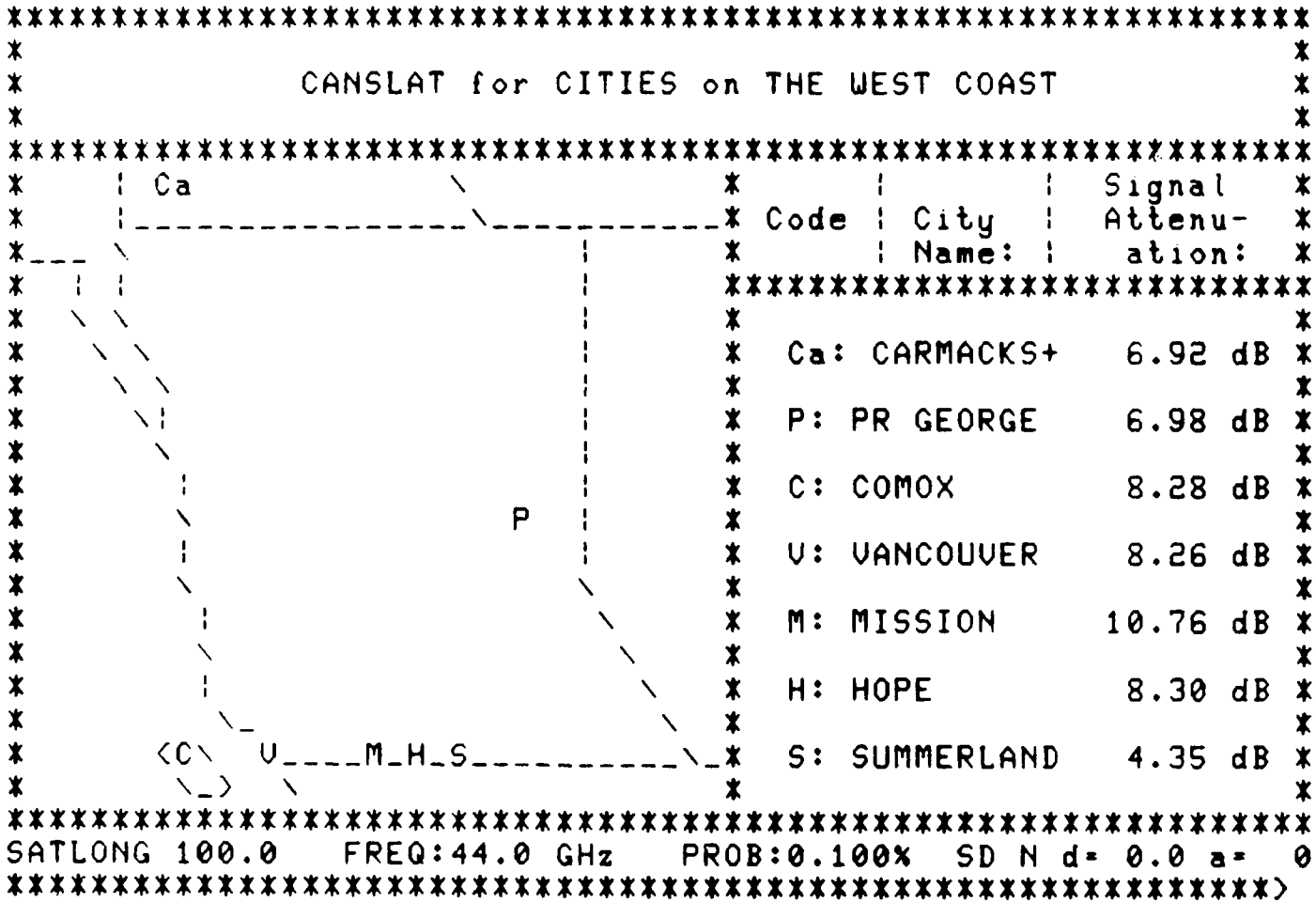

CANSLAT for CITIES on THE WEST COAST
Ca
P
C
V
M
H
S
Code
City Name:
Signal Attenu-ation:
Ca: CARMACKS+ 6.92 dB
P: PR GEORGE 6.98 dB
C: COMOX 8.28 dB
V: VANCOUVER 8.26 dB
M: MISSION 10.76 dB
H: HOPE 8.30 dB
S: SUMMERLAND 4.35 dB
SATLONG 100.0 FREQ:44.0 GHz PROB:0.100% SD N d= 0.0 a= 0

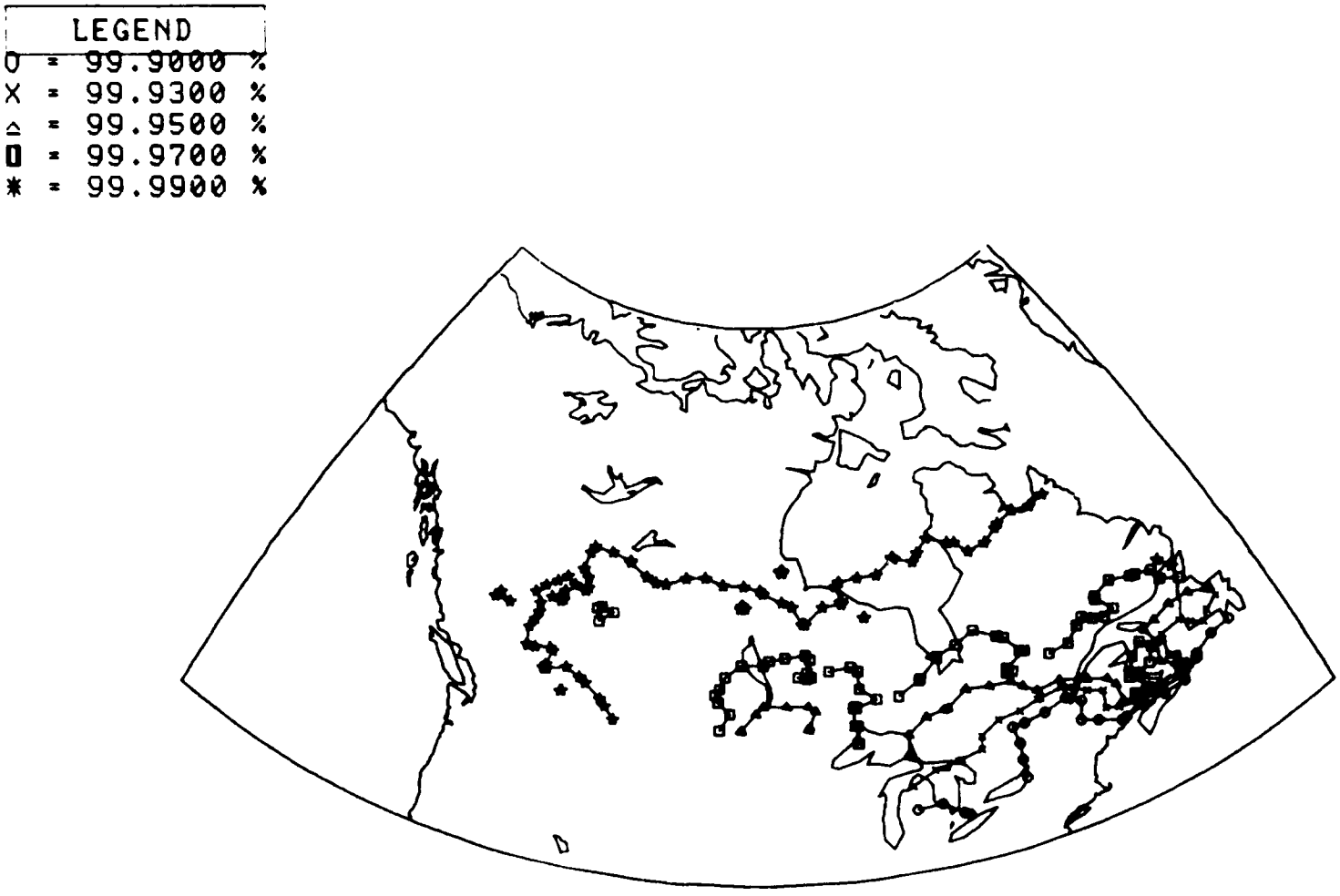
Fig. 63

Figs. 64-66 (pages 142-144)

Link availability Av contours for a major part of Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for the following values of link margin LM to overcome rain fade.

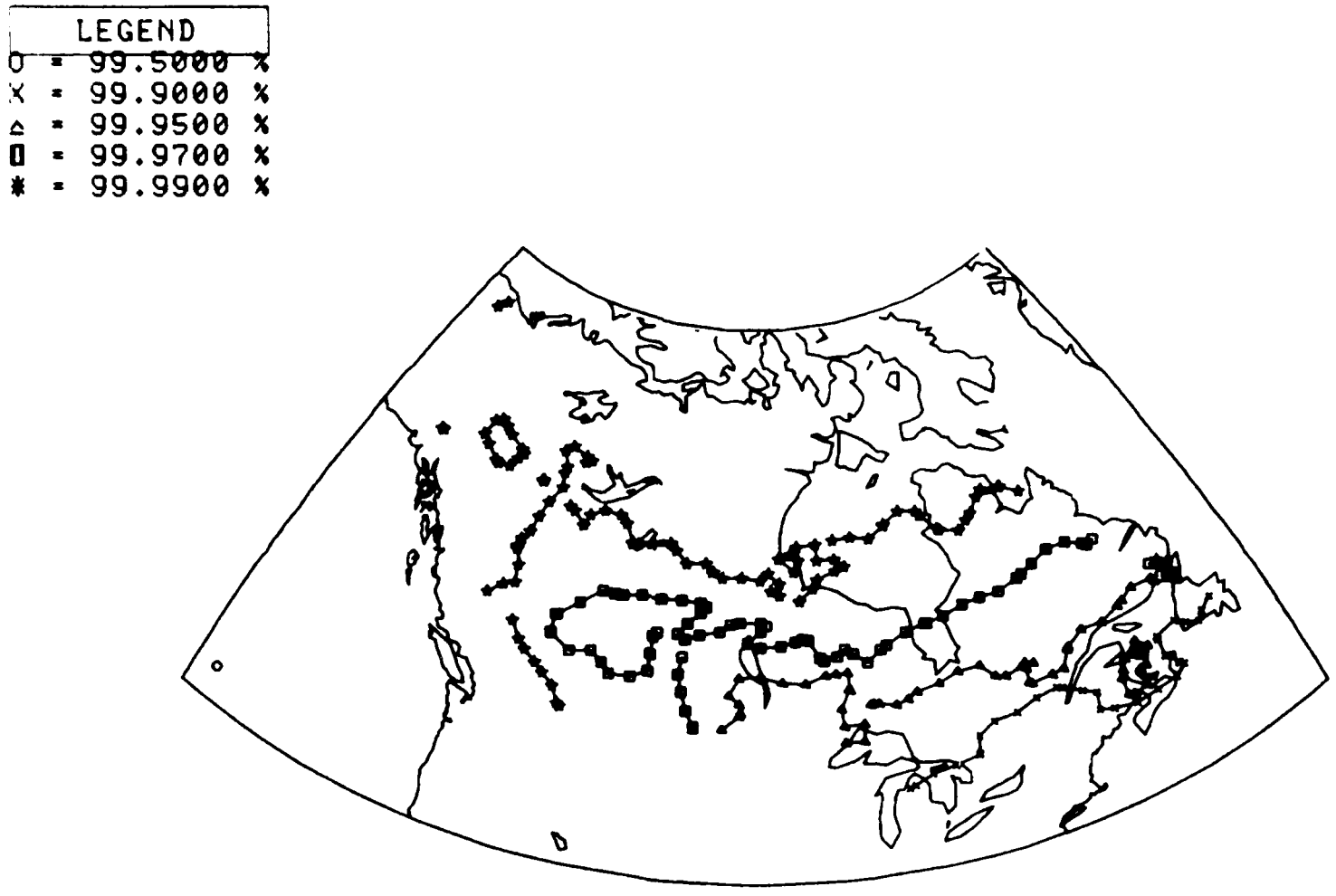
The legend gives the link availability values for the contours. The longitude of the satellite is 100° W and there is no site diversity. The latitude and longitude of the boundaries are indicated.

Frequency	Link Margin for Rain Fade
20 GHz	6 dB
30 GHz	10 dB
44 GHz	16 dB



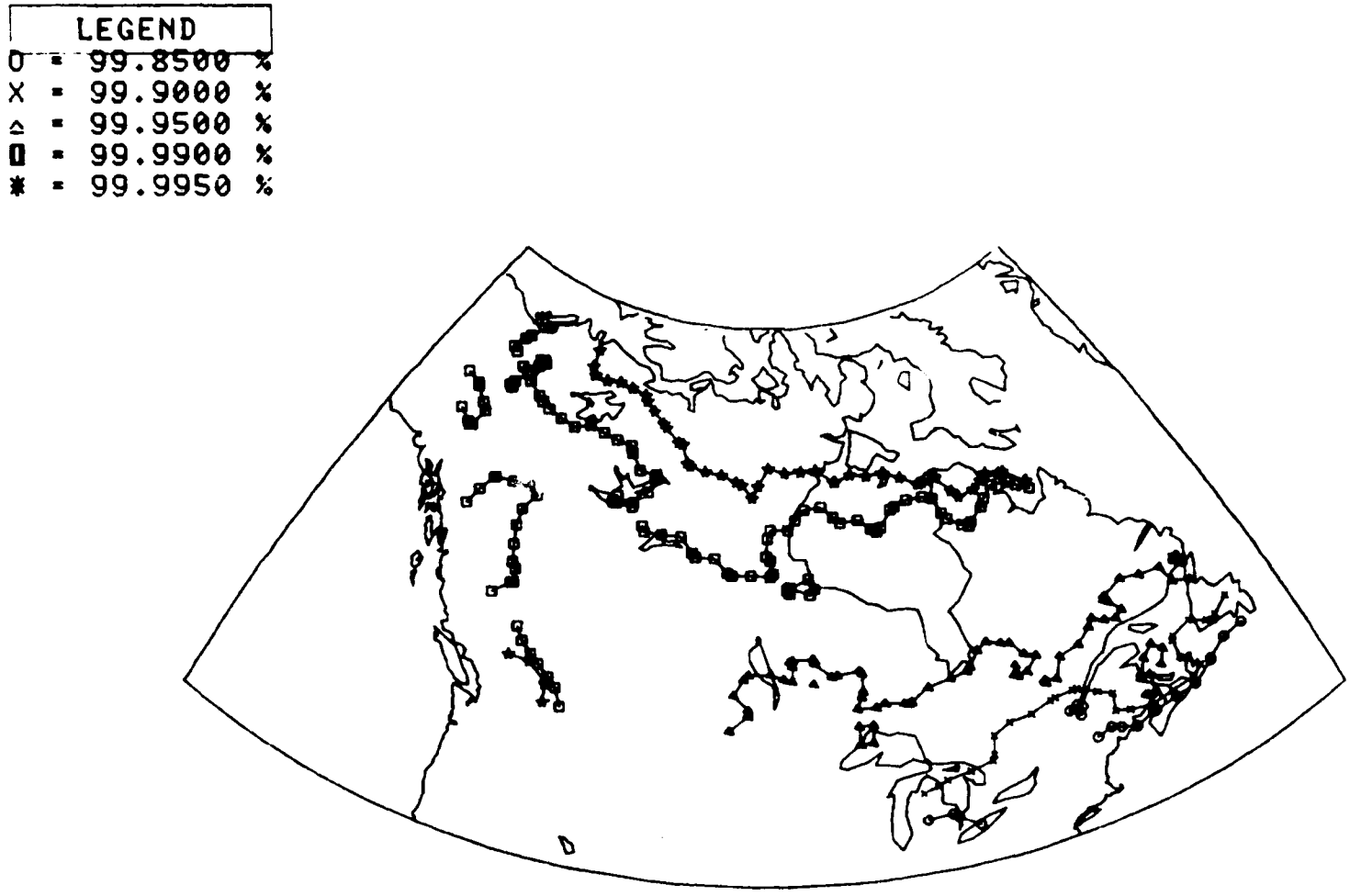
CANSLAV; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
LINK MARGIN IS 6.00 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 64



CANSLAV; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
LINK MARGIN IS 10.00 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

Fig. 65



CANSLAV; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
LINK MARGIN IS 16.00 dB
CANADA MAP: LONMN 145 LONMX 50 LATMN 40 LATMX 72

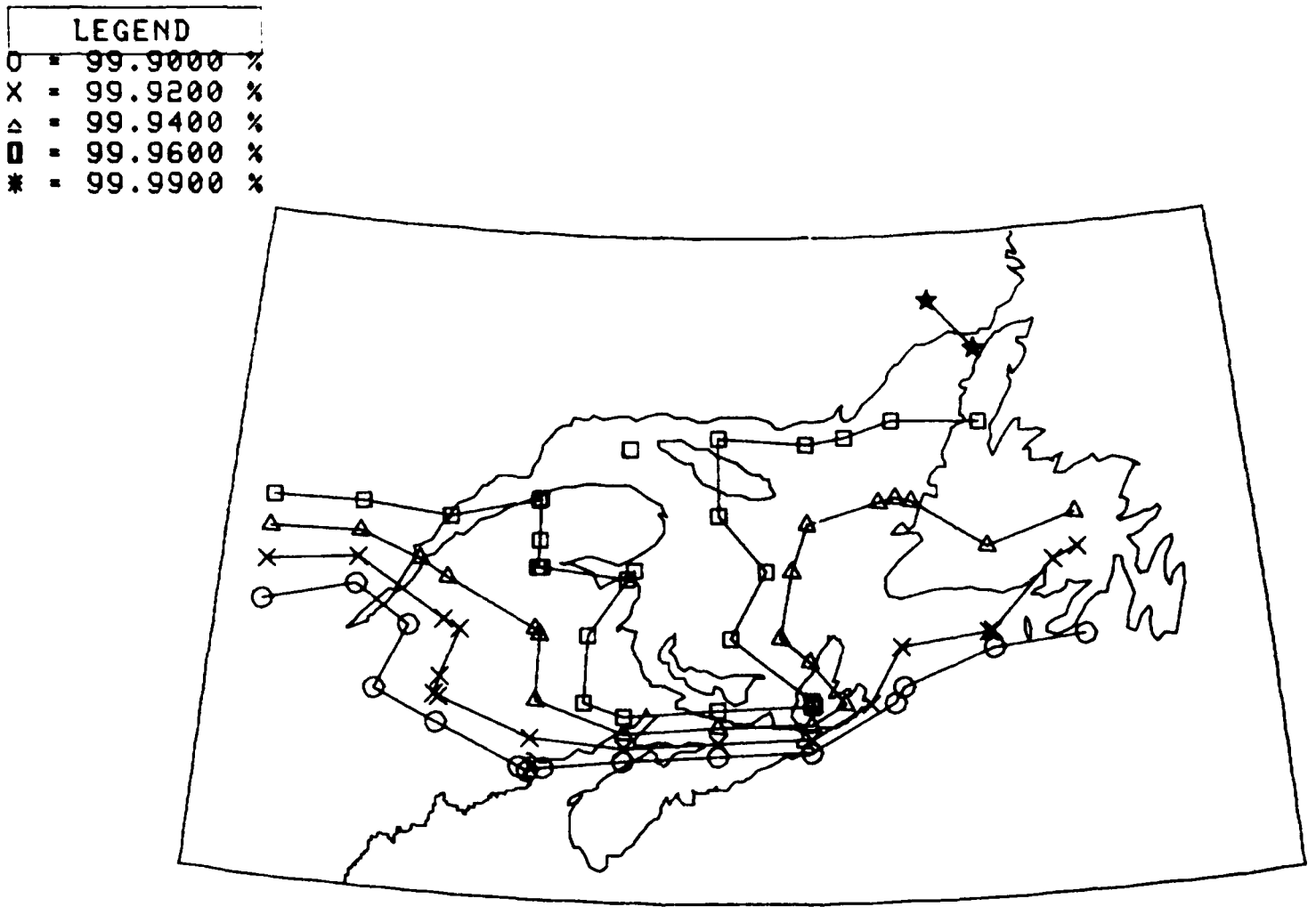
Fig. 66

Figs. 67-78 (pages 146-157)

Link availability contours for selected regions in Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for the following values of link margin LM to overcome rain fade.

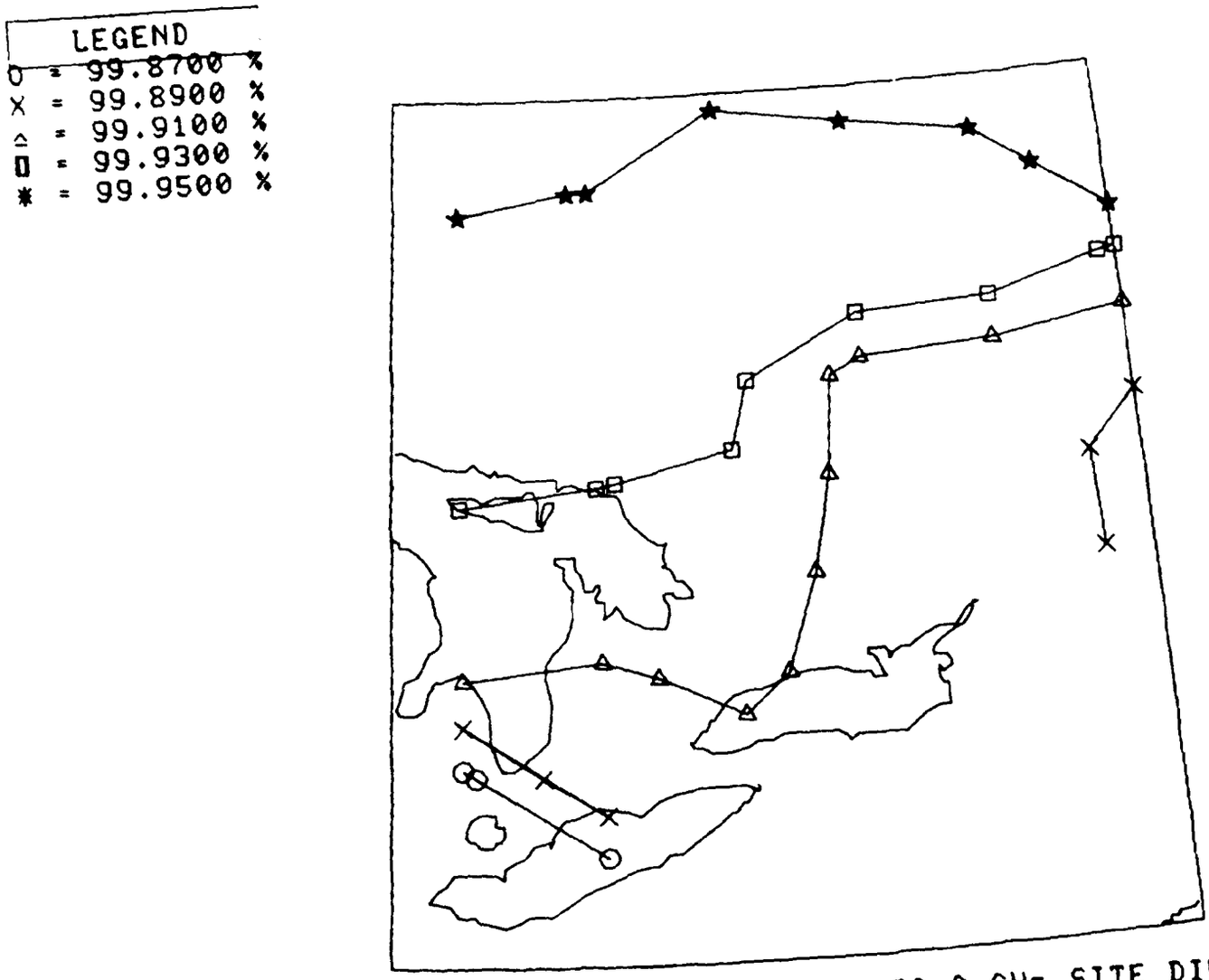
The legend gives the link availability values for the contours. The longitude of the satellite is 100° W and there is no site diversity. The latitude and longitude of the boundaries are indicated.

Frequency	Link Margin for Rain Fade
20 GHz	6 dB
30 GHz	10 dB
44 GHz	16 dB



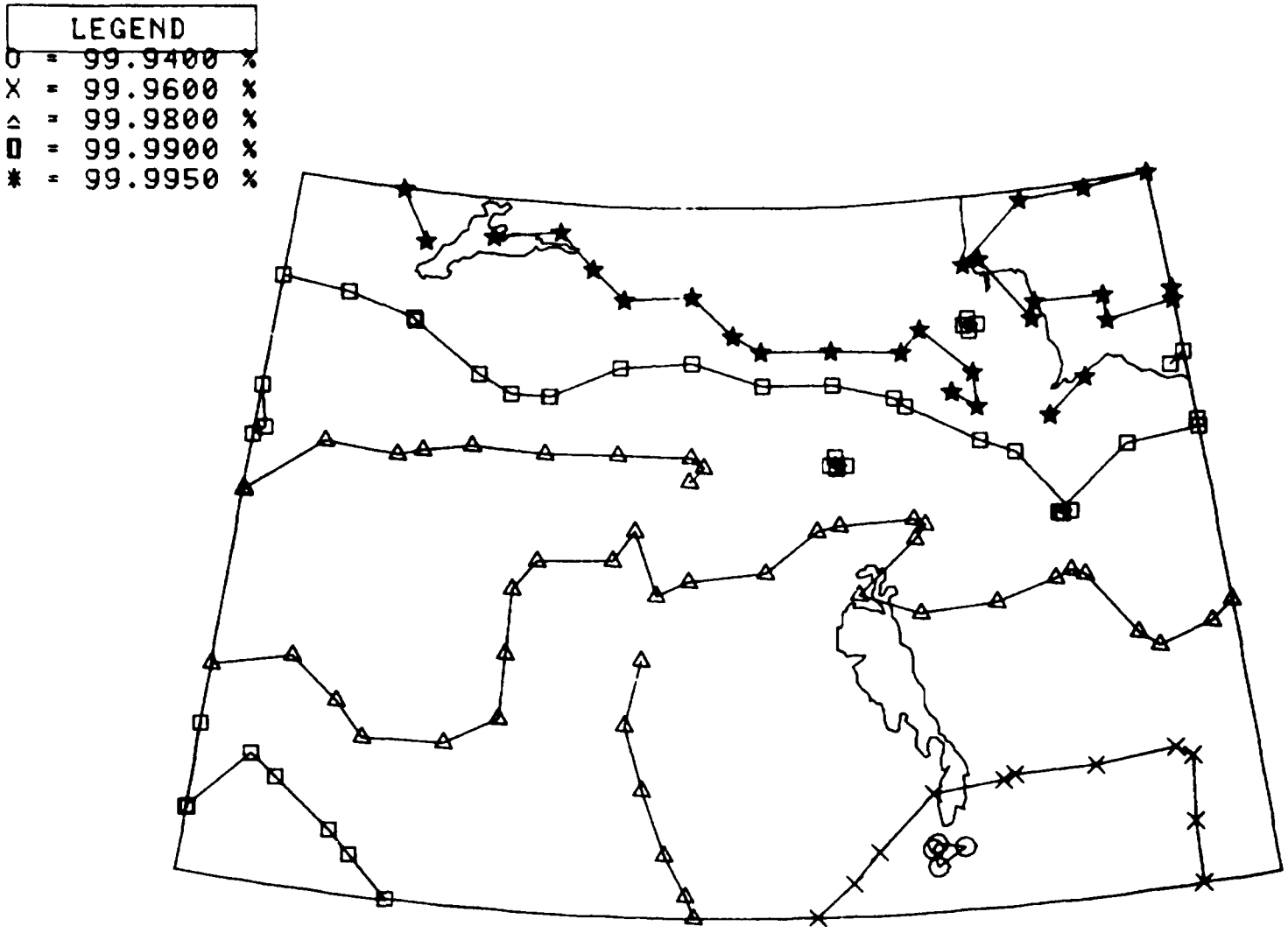
CANSLAV; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
LINK MARGIN IS 6.00 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 67



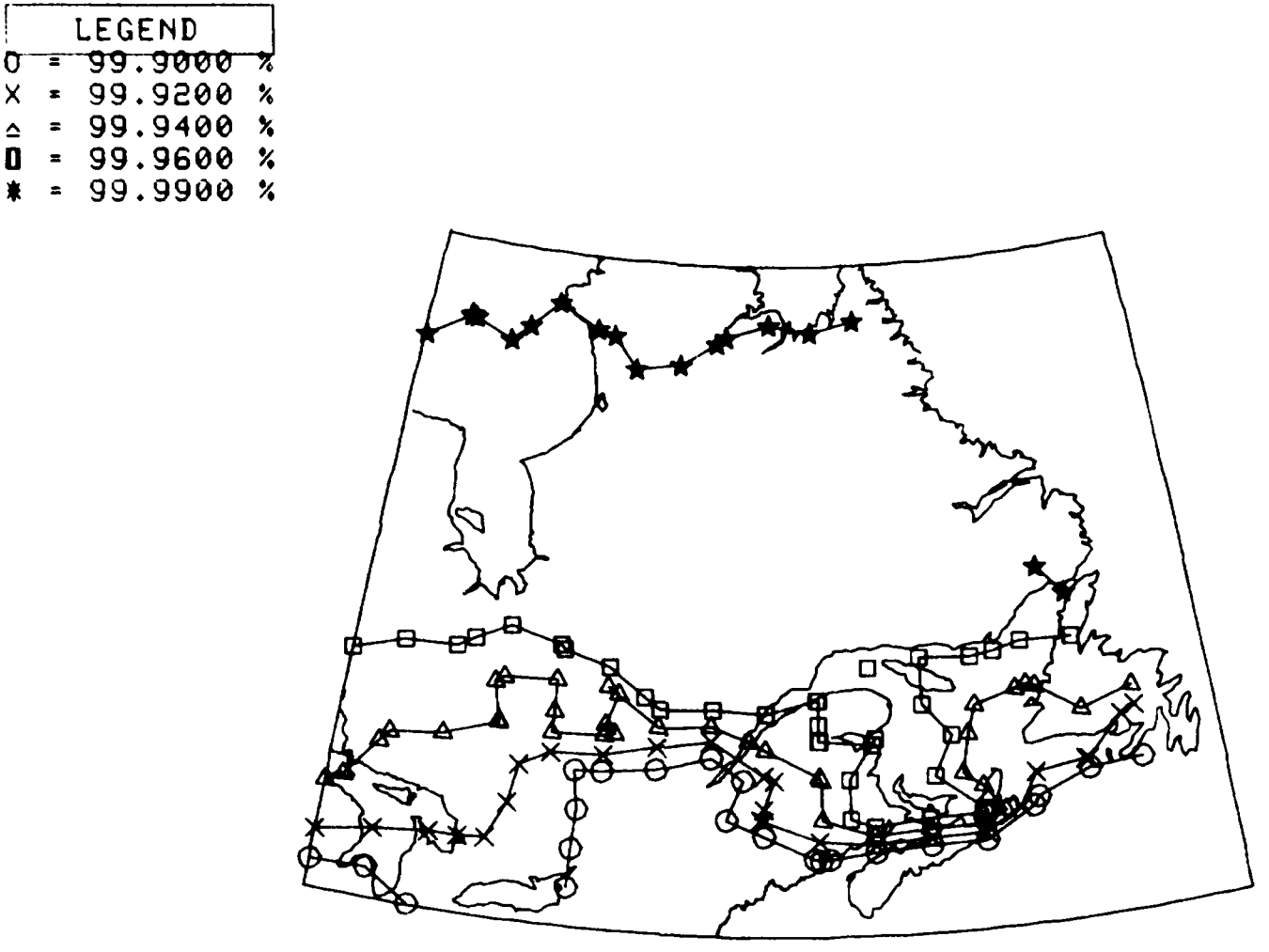
CANSLAV; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
LINK MARGIN IS 6.00 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 68



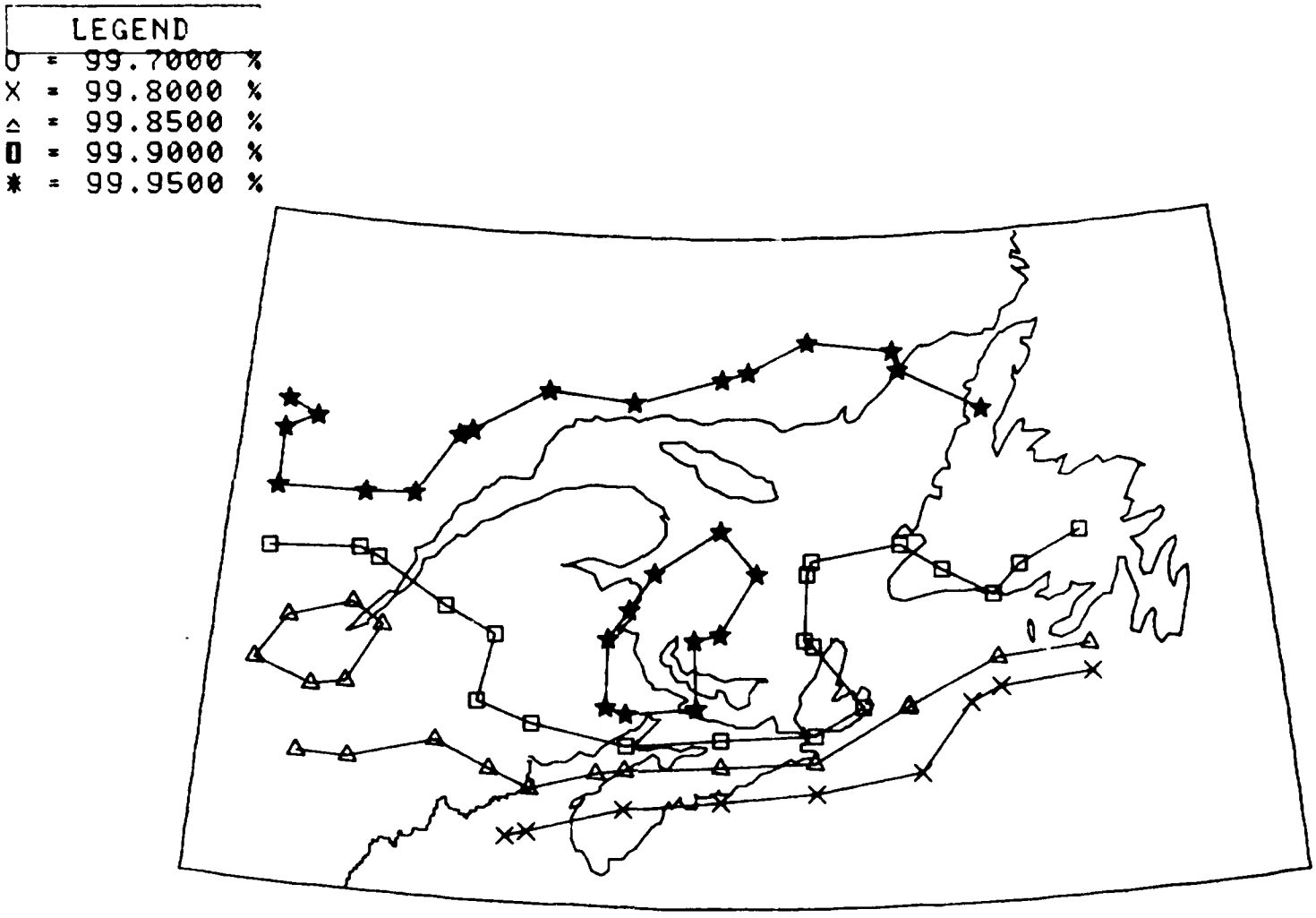
CANSLAV; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
LINK MARGIN IS 6.00 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 69



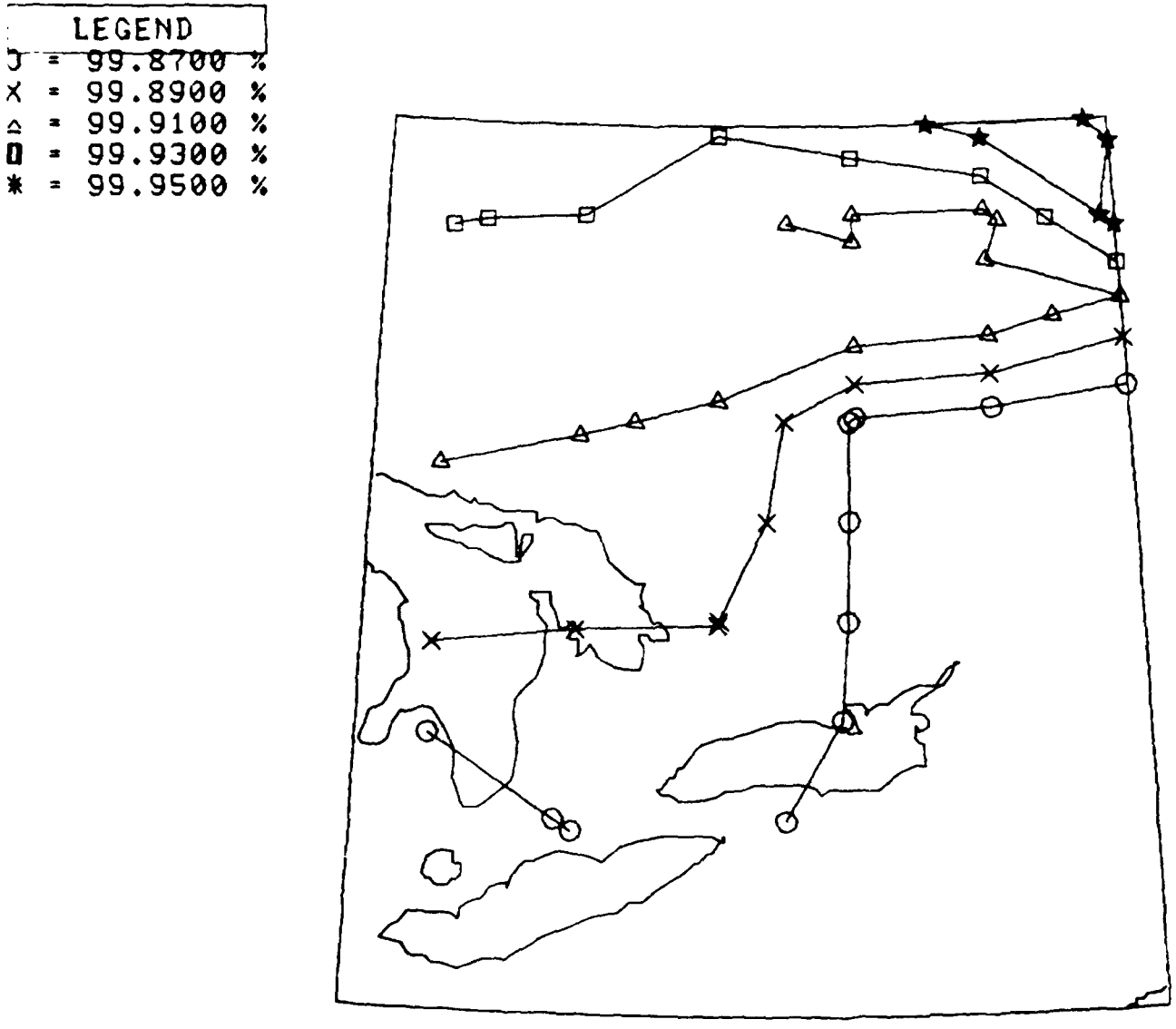
CANSLAV; SLONG: 100.0 FREQ.: 20.0 GHz SITE DIV.: N
LINK MARGIN IS 6.00 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 70



CANSLAV; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
LINK MARGIN IS 10.00 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 71



CANSLAV; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
LINK MARGIN IS 10.00 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 72

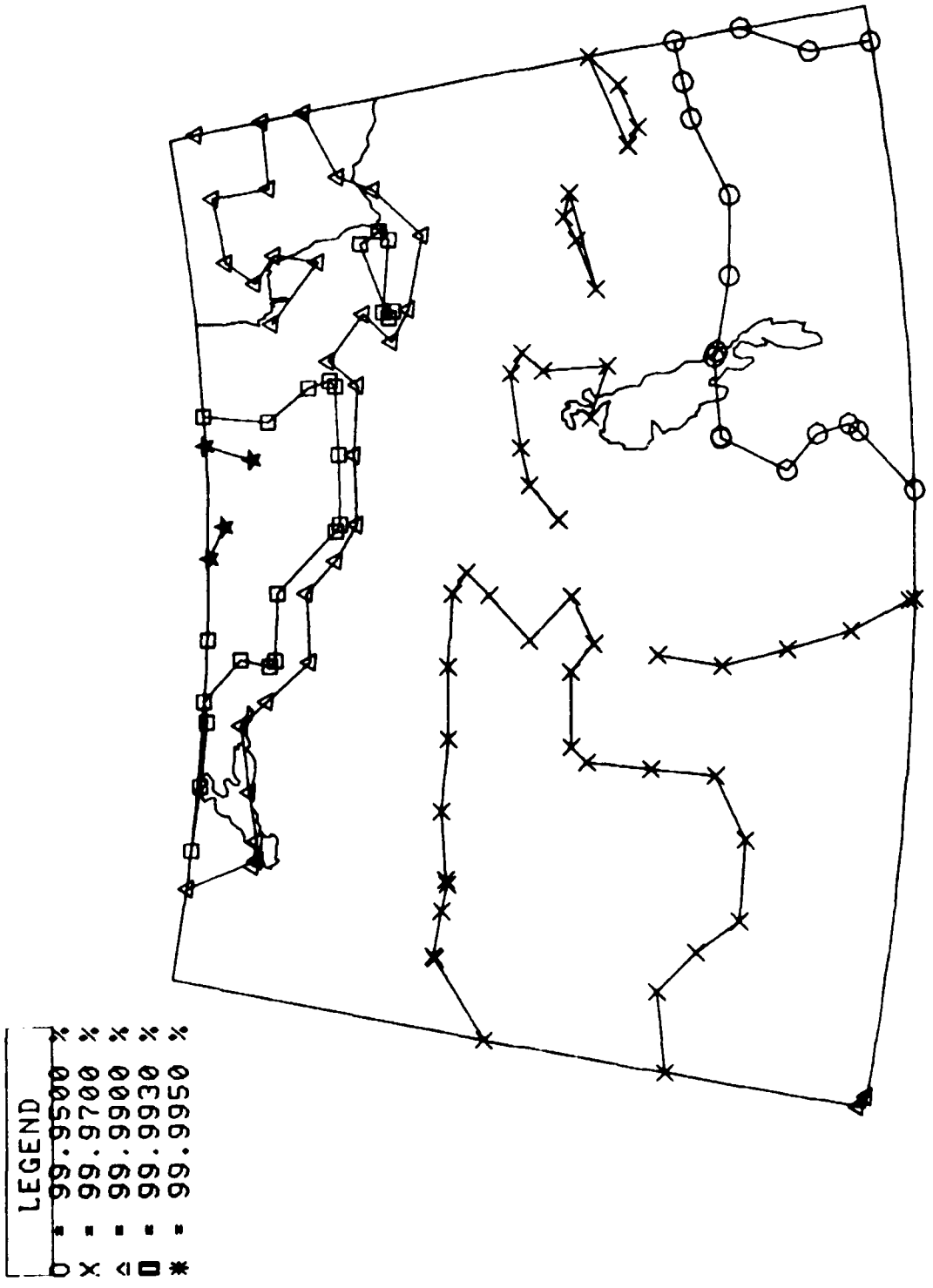
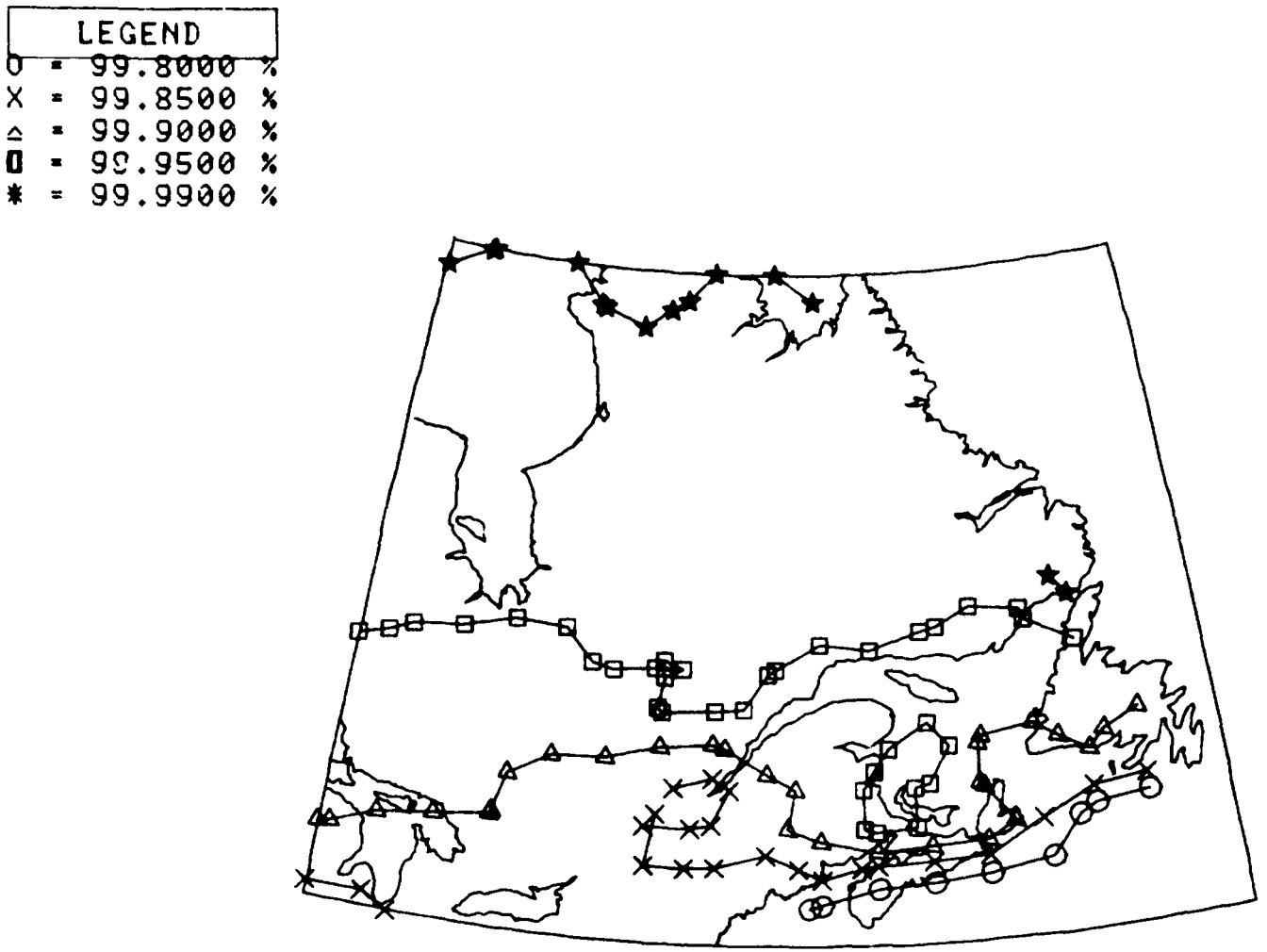

LEGEND
O = 99.9500 %
X = 99.9700 %
△ = 99.9900 %
□ = 99.9930 %
* = 99.9950 %
CANSLAV; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
LINK MARGIN IS 10.00 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 73



CANSLAV; SLONG: 100.0 FREQ.: 30.0 GHz SITE DIV.: N
LINK MARGIN IS 10.00 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 74

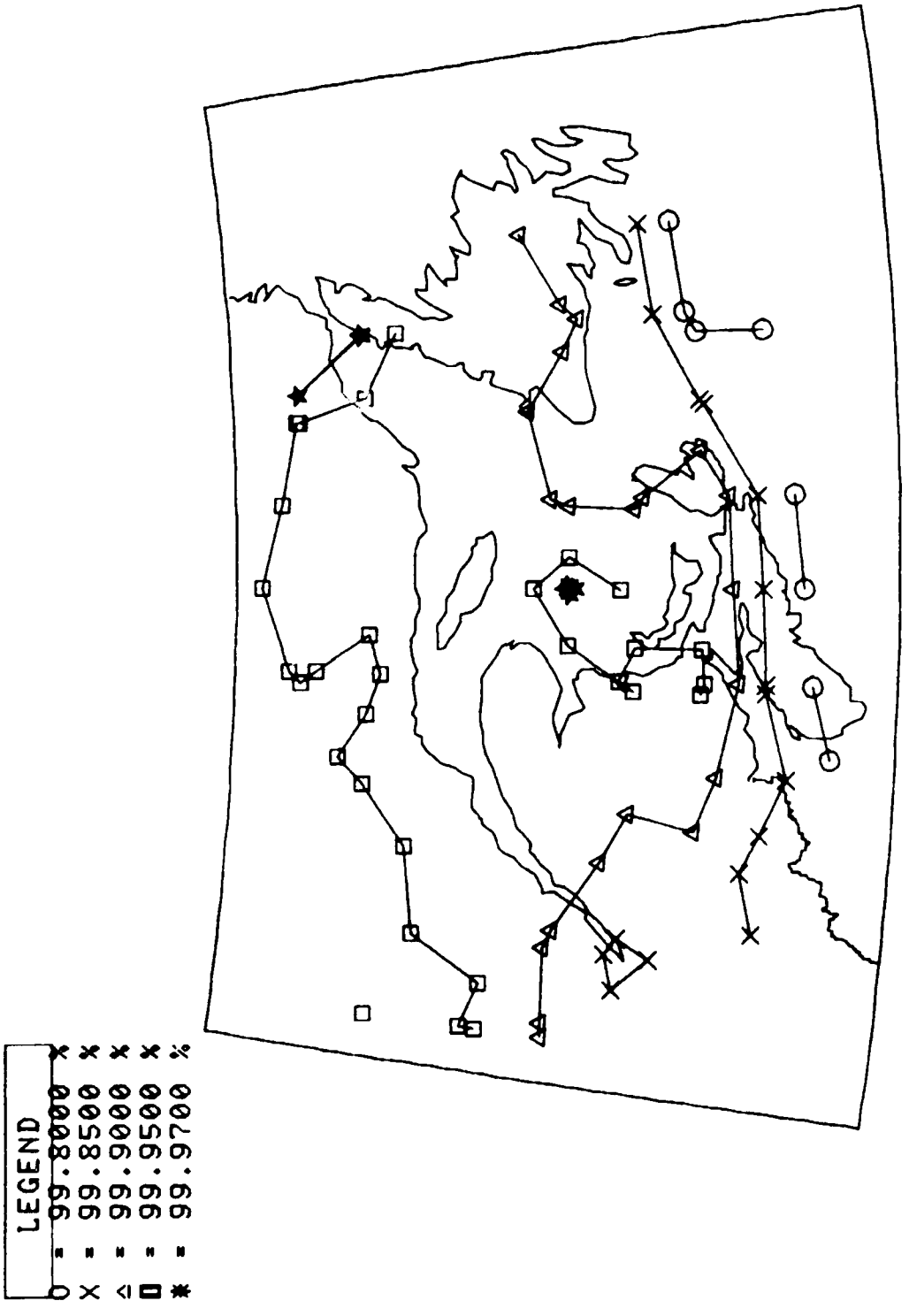
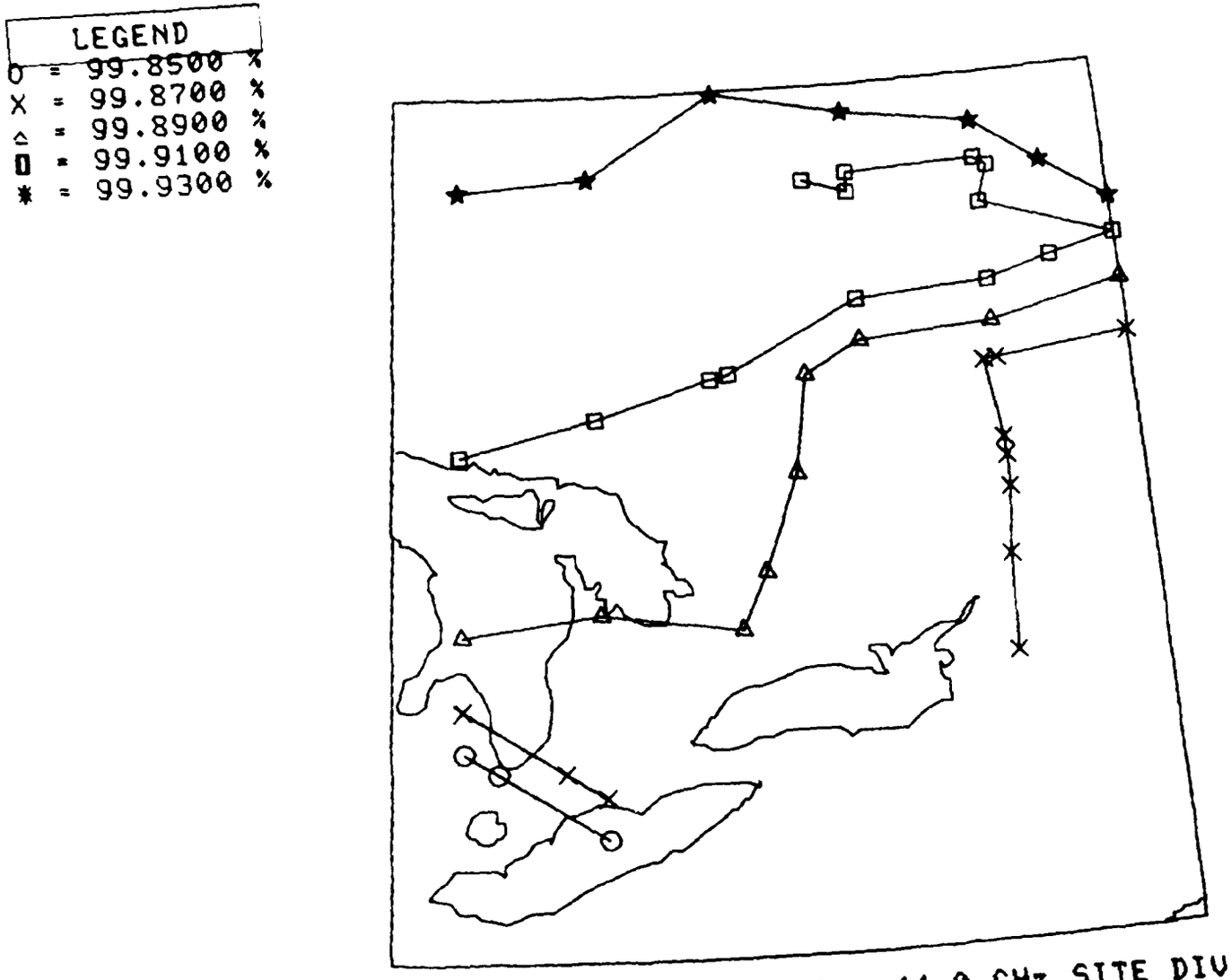

LEGEND
99.8000 %
99.8500 %
99.9000 %
99.9500 %
99.9700 %
CANSLAV; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
LINK MARGIN IS 16.00 dB
EAST COAST: LONMN 74 LONMX 51 LATMN 43 LATMX 53

Fig. 75



CANSLAV; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
LINK MARGIN IS 16.00 dB
CENTRAL CAN. LONMN 84 LONMX 73 LATMN 41 LATMX 50

Fig. 76

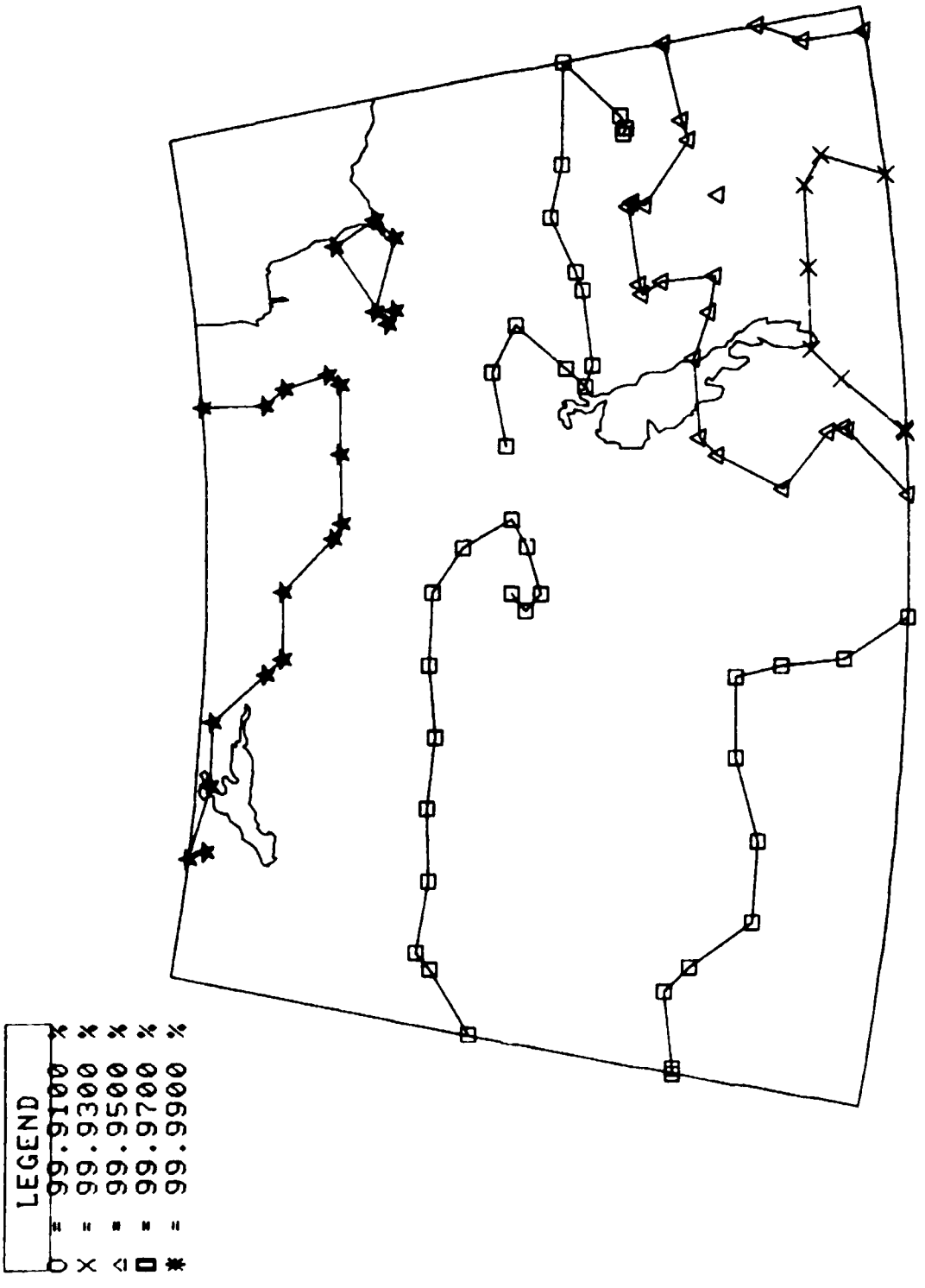
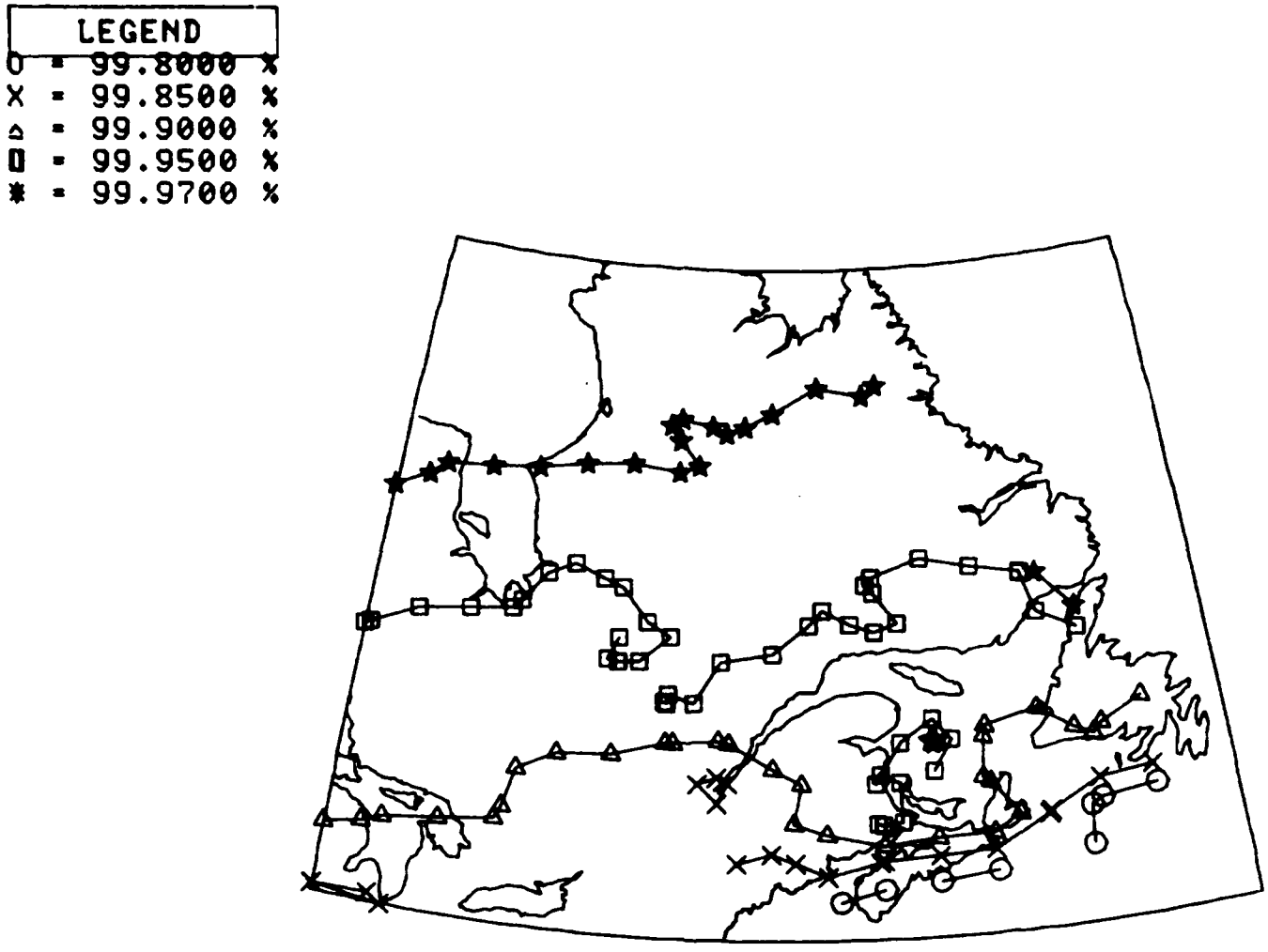

LEGEND
○ = 99.9100 %
× = 99.9300 %
△ = 99.9500 %
□ = 99.9700 %
✱ = 99.9900 %
CANSLAV; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
LINK MARGIN IS 16.00 dB
PRAIRIE CAN. LONMN 115 LONMX 89 LATMN 49 LATMX 60

Fig. 77



CANSLAV; SLONG: 100.0 FREQ.: 44.0 GHz SITE DIV.: N
LINK MARGIN IS 16.00 dB
USER SPECIF. LONMN 85 LONMX 52 LATMN 43 LATMX 60

Fig. 78

Figs. 79-93 (pages 159-173)

Link availability values for selected sites in different parts of Canada for an earth-satellite path in a geostationary link at 20, 30 and 44 GHz for the following values of link margin LM to overcome rain fade.

The longitude of the satellite is 100° W and there is no site diversity. Approximate position of the site is shown on a coarse map.

Frequency	Link Margin for Rain Fade
20 GHz	6 dB
30 GHz	10 dB
44 GHz	16 dB

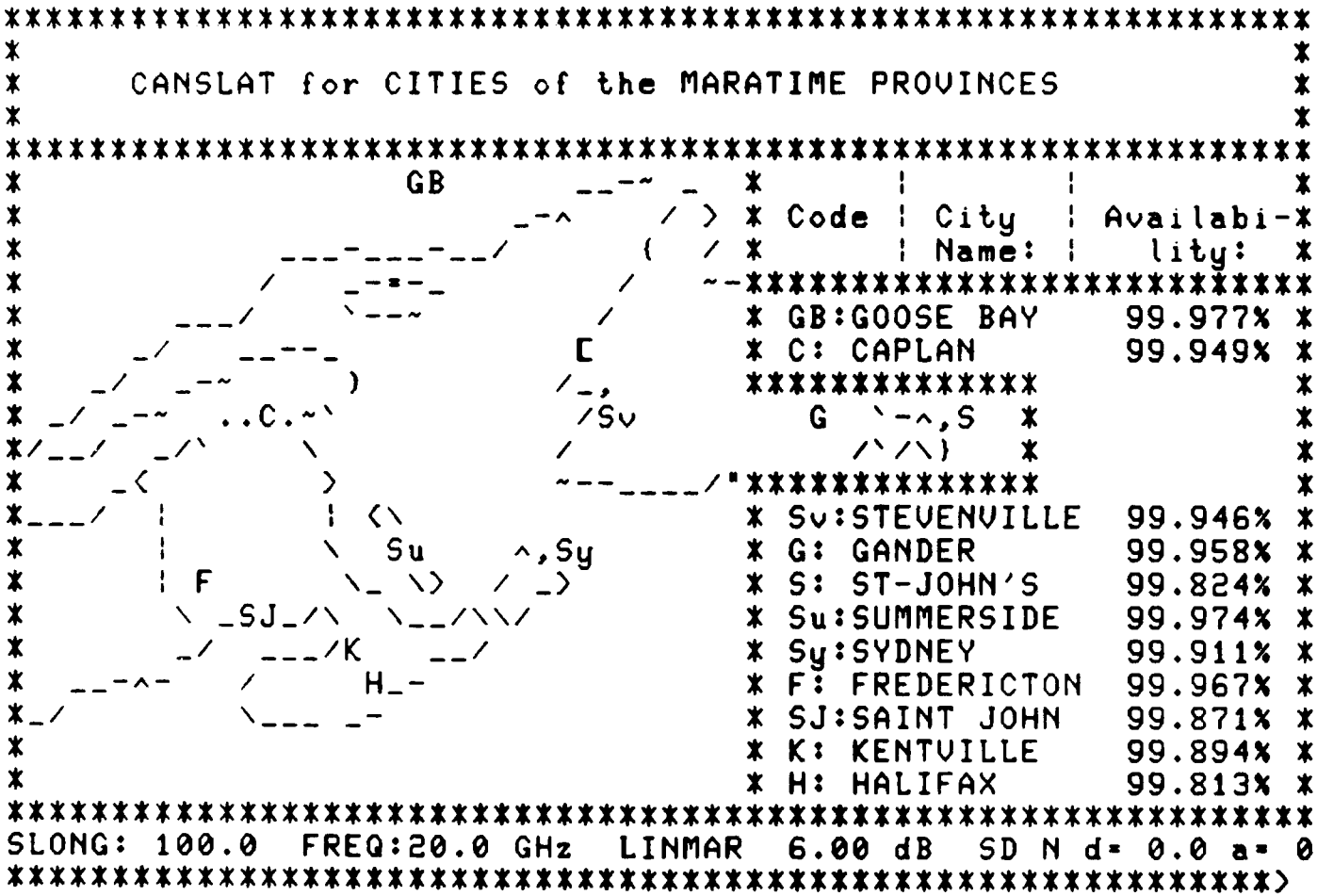

CANSLAT for CITIES of the MARATIME PROVINCES
GB
Su
Sy
Sv
F
SJ
K
H
C
G
S
Code | City Name: | Availability:
GB:GOOSE BAY 99.977%
C: CAPLAN 99.949%
Sv:STEVENVILLE 99.946%
G: GANDER 99.958%
S: ST-JOHN'S 99.824%
Su:SUMMERSIDE 99.974%
Sy:SYDNEY 99.911%
F: FREDERICTON 99.967%
SJ:SAINT JOHN 99.871%
K: KENTVILLE 99.894%
H: HALIFAX 99.813%
SLONG: 100.0 FREQ:20.0 GHz LINMAR 6.00 dB SD N d= 0.0 a= 0

Fig. 79

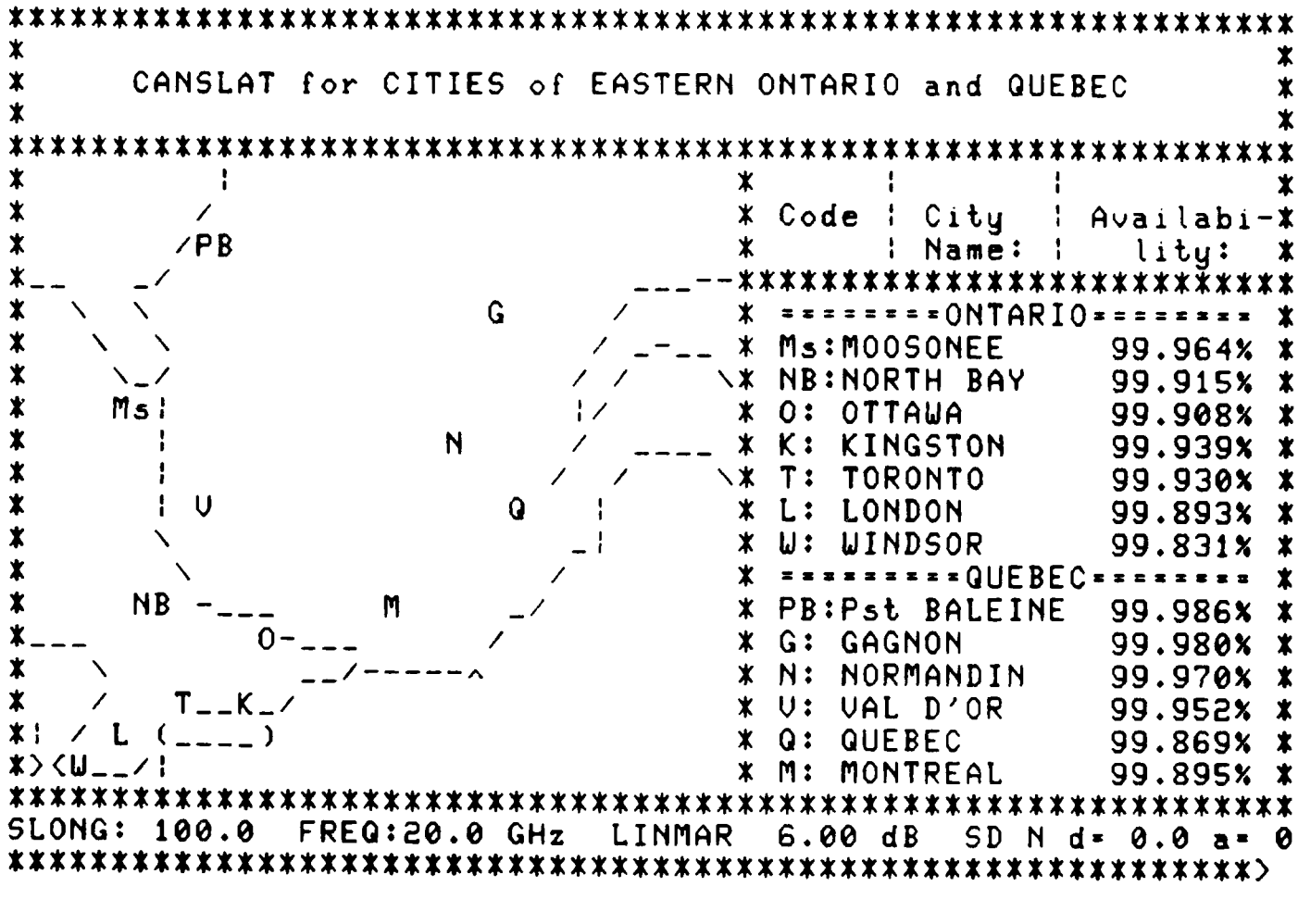

CANSLAT for CITIES of EASTERN ONTARIO and QUEBEC
Code | City Name: | Availability:
ONTARIO
Ms: MOOSONEE 99.964%
NB: NORTH BAY 99.915%
O: OTTAWA 99.908%
K: KINGSTON 99.939%
T: TORONTO 99.930%
L: LONDON 99.893%
W: WINDSOR 99.831%
QUEBEC
PB: Pst BALEINE 99.986%
G: GAGNON 99.980%
N: NORMANDIN 99.970%
V: VAL D'OR 99.952%
Q: QUEBEC 99.869%
M: MONTREAL 99.895%
SLONG: 100.0 FREQ:20.0 GHz LINMAR 6.00 dB SD N d= 0.0 a= 0

Fig. 80

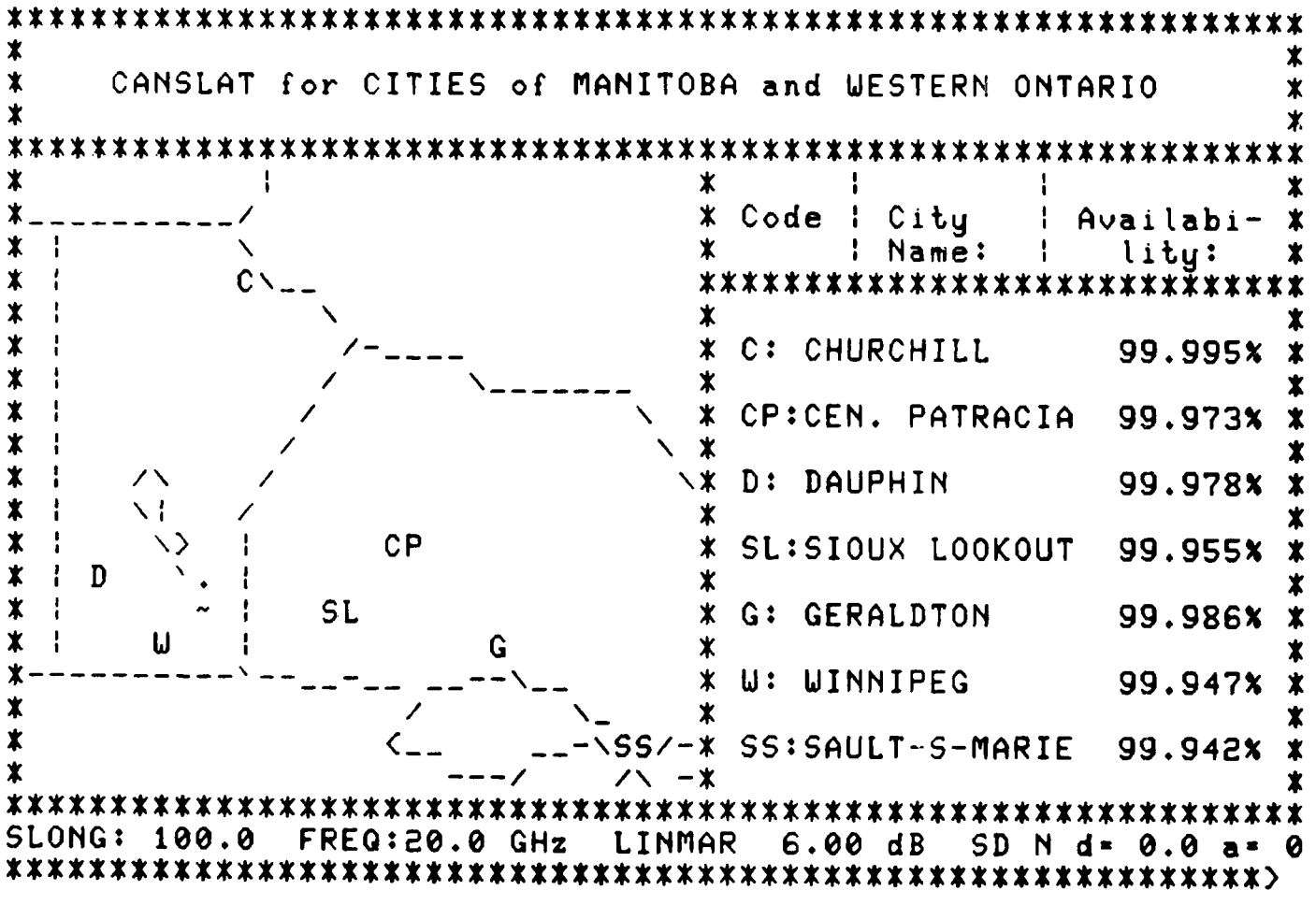

CANSLAT for CITIES of MANITOBA and WESTERN ONTARIO
Code | City Name: | Availability:
C: CHURCHILL 99.995%
CP:CEN. PATRACIA 99.973%
D: DAUPHIN 99.978%
SL:SIOUX LOOKOUT 99.955%
G: GERALDTON 99.986%
W: WINNIPEG 99.947%
SS:SAULT-S-MARIE 99.942%
C
CP
D
SL
G
W
SS
SLONG: 100.0 FREQ:20.0 GHz LINMAR 6.00 dB SD N d= 0.0 a= 0

Fig. 81

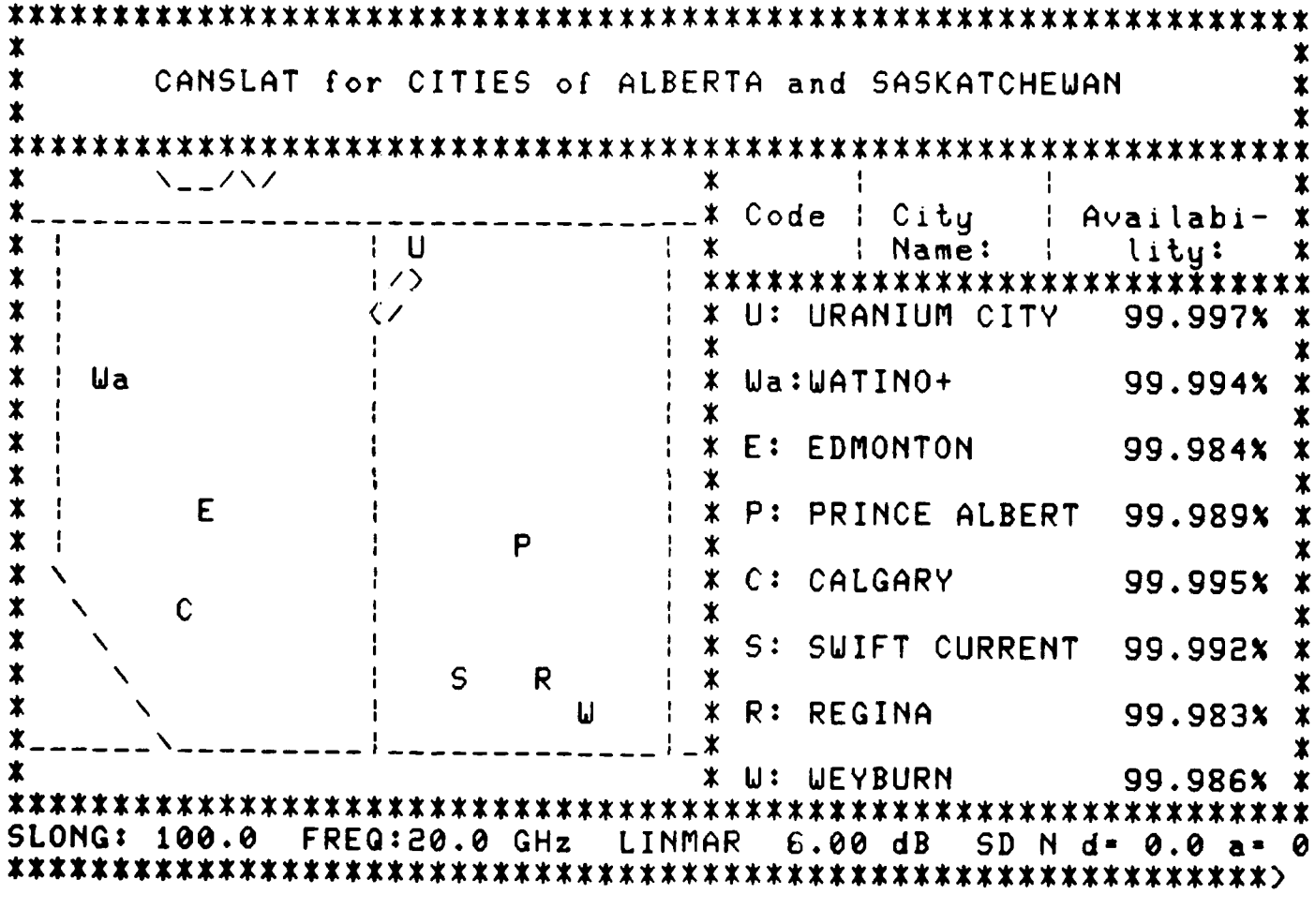

CANSLAT for CITIES of ALBERTA and SASKATCHEWAN
Code
City Name:
Availability:
U: URANIUM CITY 99.997%
Wa:WATINO+ 99.994%
E: EDMONTON 99.984%
P: PRINCE ALBERT 99.989%
C: CALGARY 99.995%
S: SWIFT CURRENT 99.992%
R: REGINA 99.983%
W: WEYBURN 99.986%
SLONG: 100.0 FREQ:20.0 GHz LINMAR 6.00 dB SD N d= 0.0 a= 0

Fig. 82

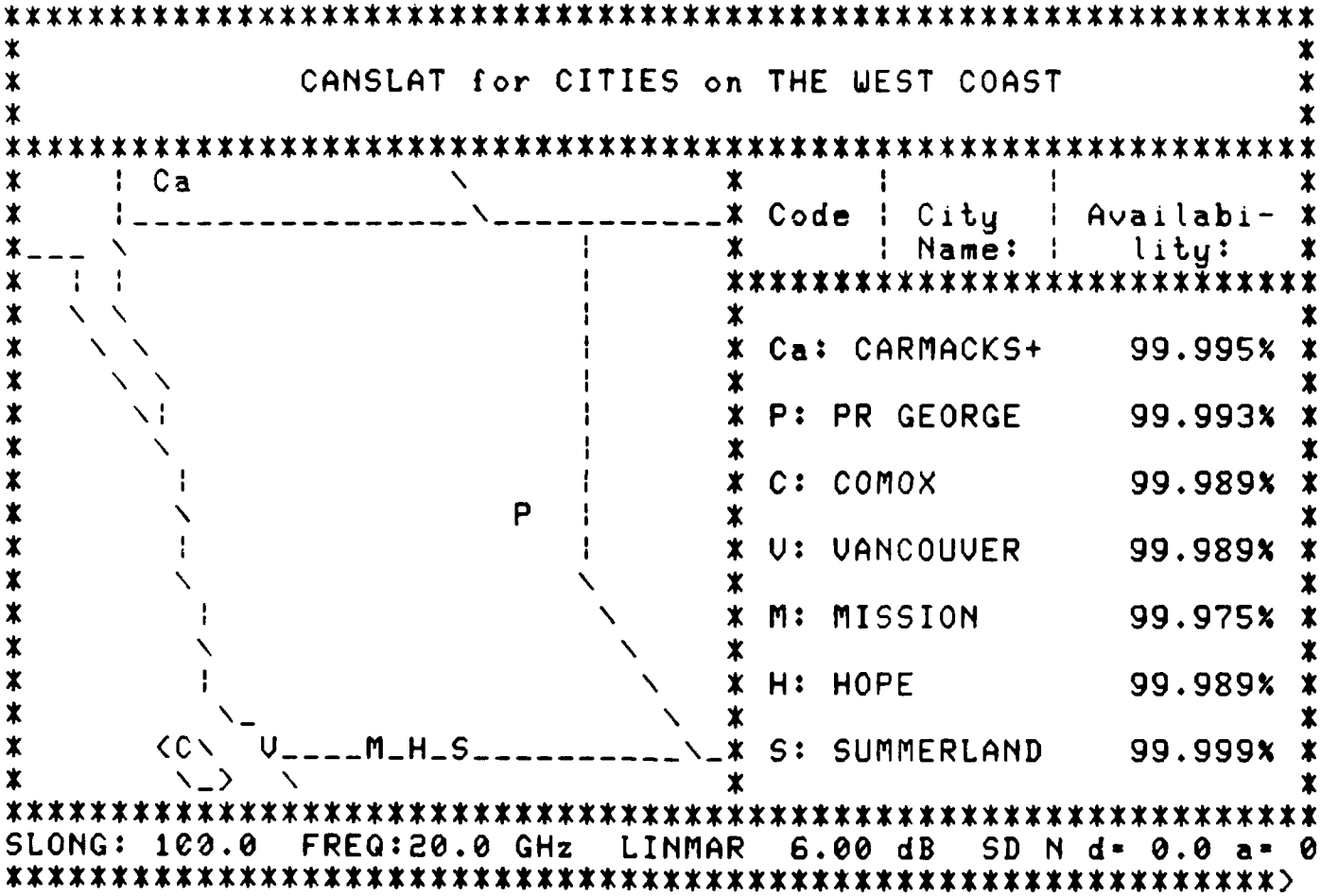

CANSLAT for CITIES on THE WEST COAST
Ca
P
<C
V
M
H
S
Code | City Name: | Availability:
Ca: CARMACKS+ 99.995%
P: PR GEORGE 99.993%
C: COMOX 99.989%
V: VANCOUVER 99.989%
M: MISSION 99.975%
H: HOPE 99.989%
S: SUMMERLAND 99.999%
SLONG: 100.0 FREQ:20.0 GHz LINMAR 6.00 dB SD N d= 0.0 a= 0

Fig. 83

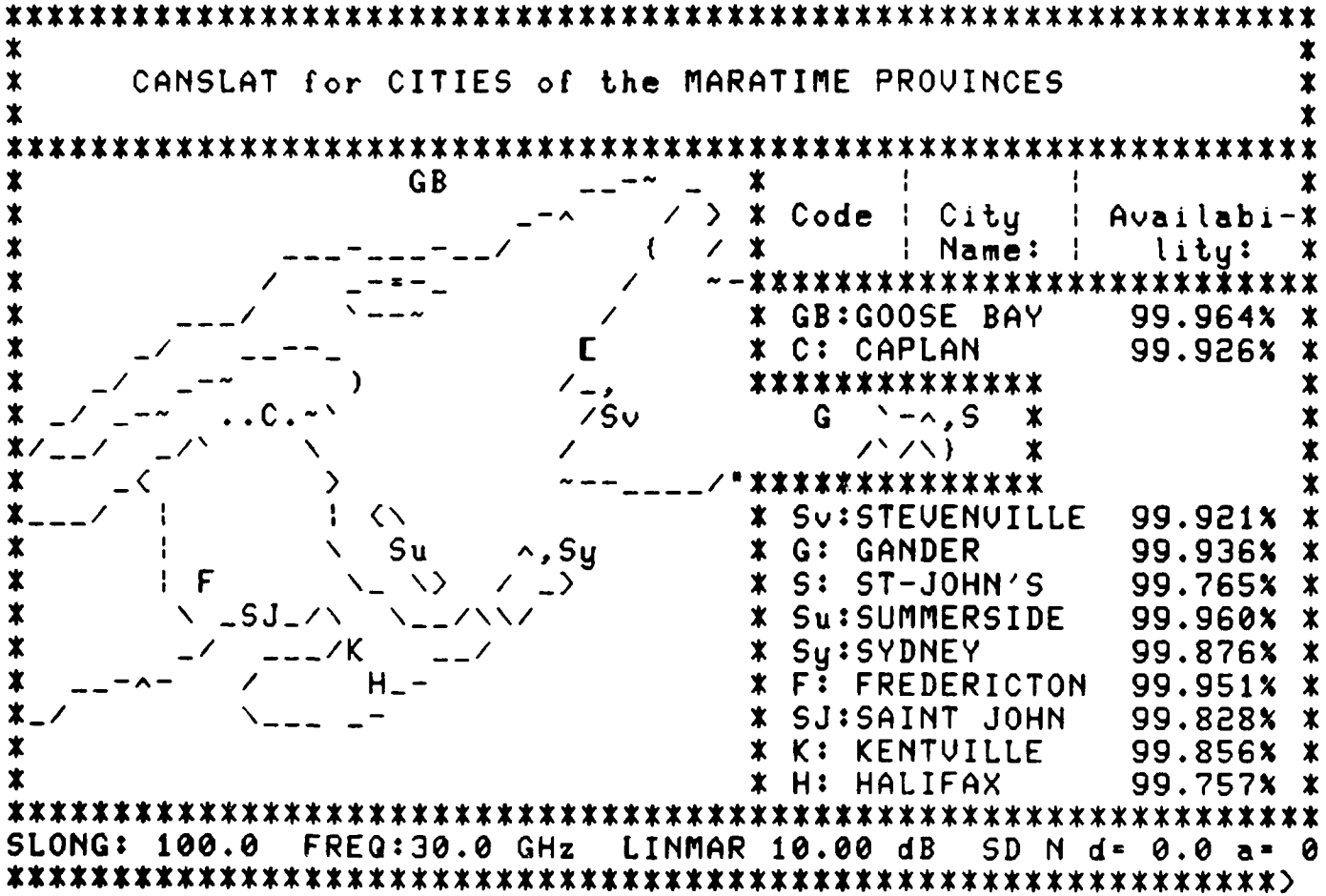
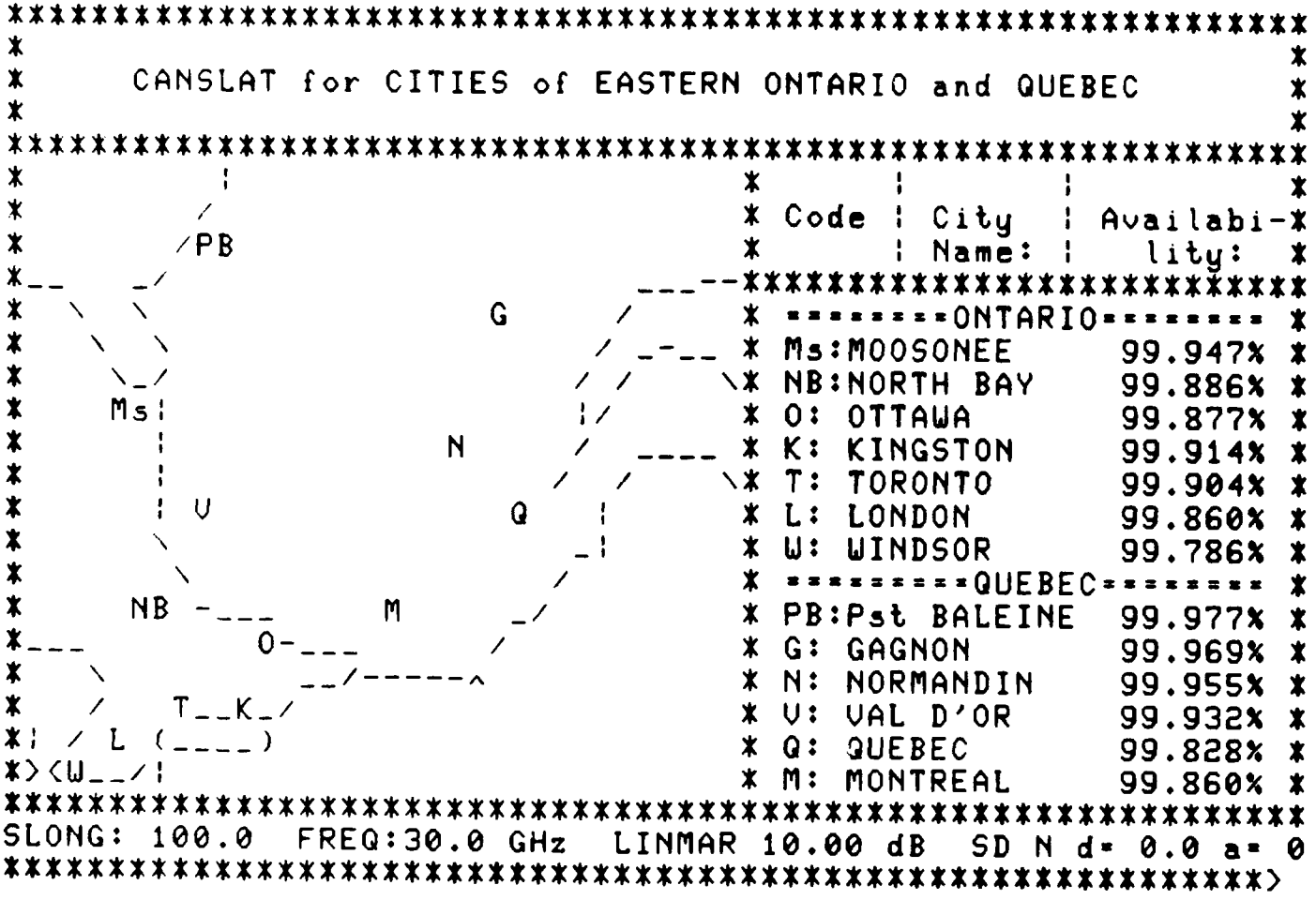

CANSLAT for CITIES of the MARATIME PROVINCES
GB
C
Sv
G
S
Su
Sy
F
SJ
K
H
Code | City Name: | Availability:
GB:GOOSE BAY 99.964%
C: CAPLAN 99.926%
Sv:STEVENVILLE 99.921%
G: GANDER 99.936%
S: ST-JOHN'S 99.765%
Su:SUMMERSIDE 99.960%
Sy:SYDNEY 99.876%
F: FREDERICTON 99.951%
SJ:SAINT JOHN 99.828%
K: KENTVILLE 99.856%
H: HALIFAX 99.757%
SLONG: 100.0 FREQ:30.0 GHz LINMAR 10.00 dB SD N d= 0.0 a= 0

Fig. 84




```
*****************************************************************
*                                                               *
*     CANSLAT for CITIES of EASTERN ONTARIO and QUEBEC          *
*                                                               *
*****************************************************************
*          |                          *      |       |           *
*         /                           * Code | City  | Availabi-*
*        /PB                          *      | Name: |   lity:  *
*__    _/                      ___--*************************
*  \   \                 G     /     * ========ONTARIO======== *
*   \   \                     / _-__ * Ms:MOOSONEE      99.947% *
*    \_/                     / /    \* NB:NORTH BAY     99.886% *
*    Ms|                    |/       * O: OTTAWA        99.877% *
*      |              N     /  ____ * K: KINGSTON      99.914% *
*      |                   /  /    \* T: TORONTO       99.904% *
*      | V               Q   |       * L: LONDON        99.860% *
*      \                    _|       * W: WINDSOR       99.786% *
*       \                  /         * =========QUEBEC======== *
*     NB -___      M     _/          * PB:Pst BALEINE   99.977% *
*___         O-___      /            * G: GAGNON        99.969% *
*   \          __/-----^             * N: NORMANDIN     99.955% *
*   /   T__K_/                       * V: VAL D'OR      99.932% *
*| / L (____)                       * Q: QUEBEC        99.828% *
*><W__/|                            * M: MONTREAL      99.860% *
*****************************************************************
SLONG: 100.0  FREQ:30.0 GHz  LINMAR 10.00 dB  SD N d= 0.0 a= 0
*****************************************************************>
```

Fig. 85

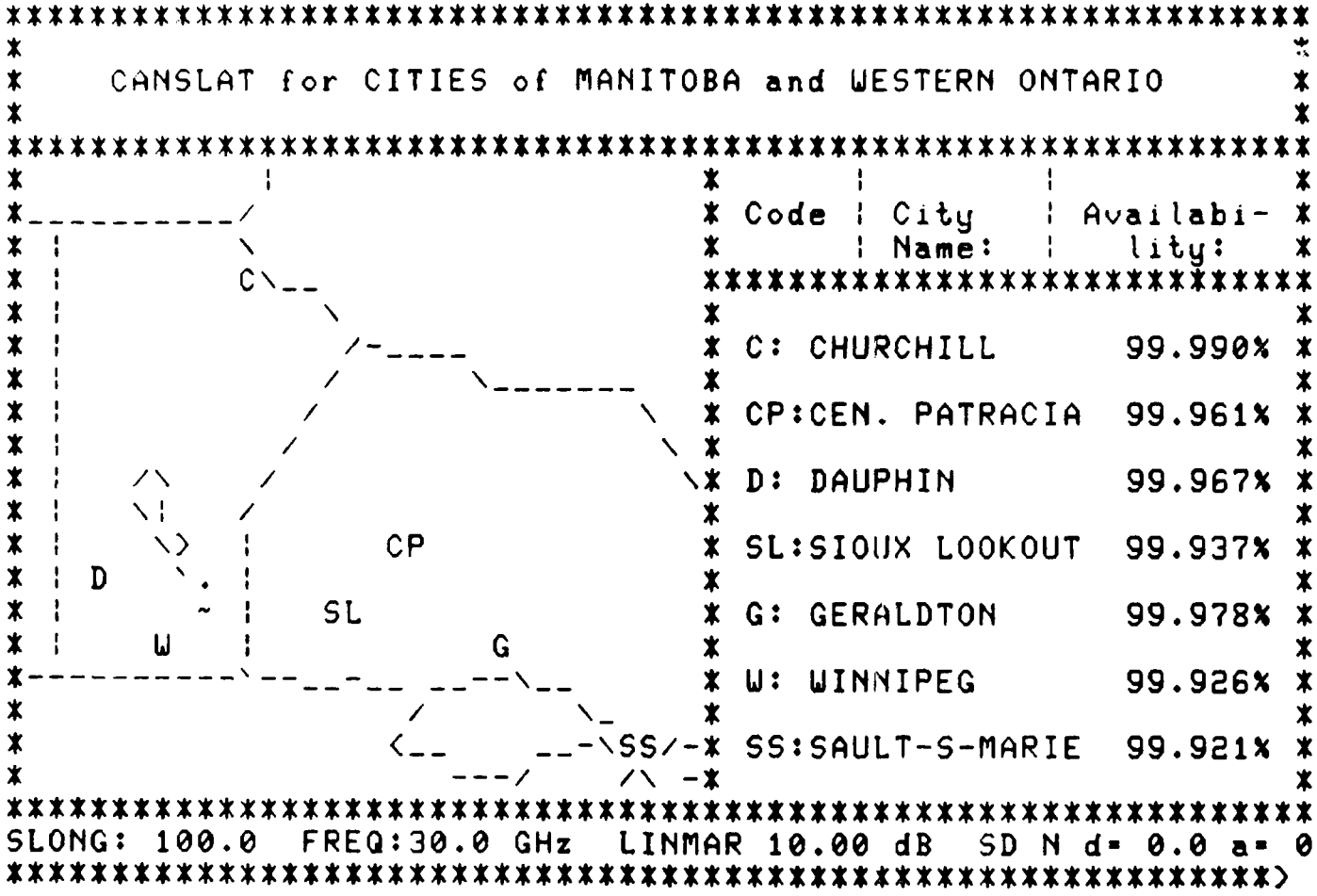

CANSLAT for CITIES of MANITOBA and WESTERN ONTARIO
Code | City Name: | Availability:
C: CHURCHILL 99.990%
CP:CEN. PATRACIA 99.961%
D: DAUPHIN 99.967%
SL:SIOUX LOOKOUT 99.937%
G: GERALDTON 99.978%
W: WINNIPEG 99.926%
SS:SAULT-S-MARIE 99.921%
C
CP
D
SL
G
W
SS
SLONG: 100.0 FREQ:30.0 GHz LINMAR 10.00 dB SD N d= 0.0 a= 0

Fig. 86

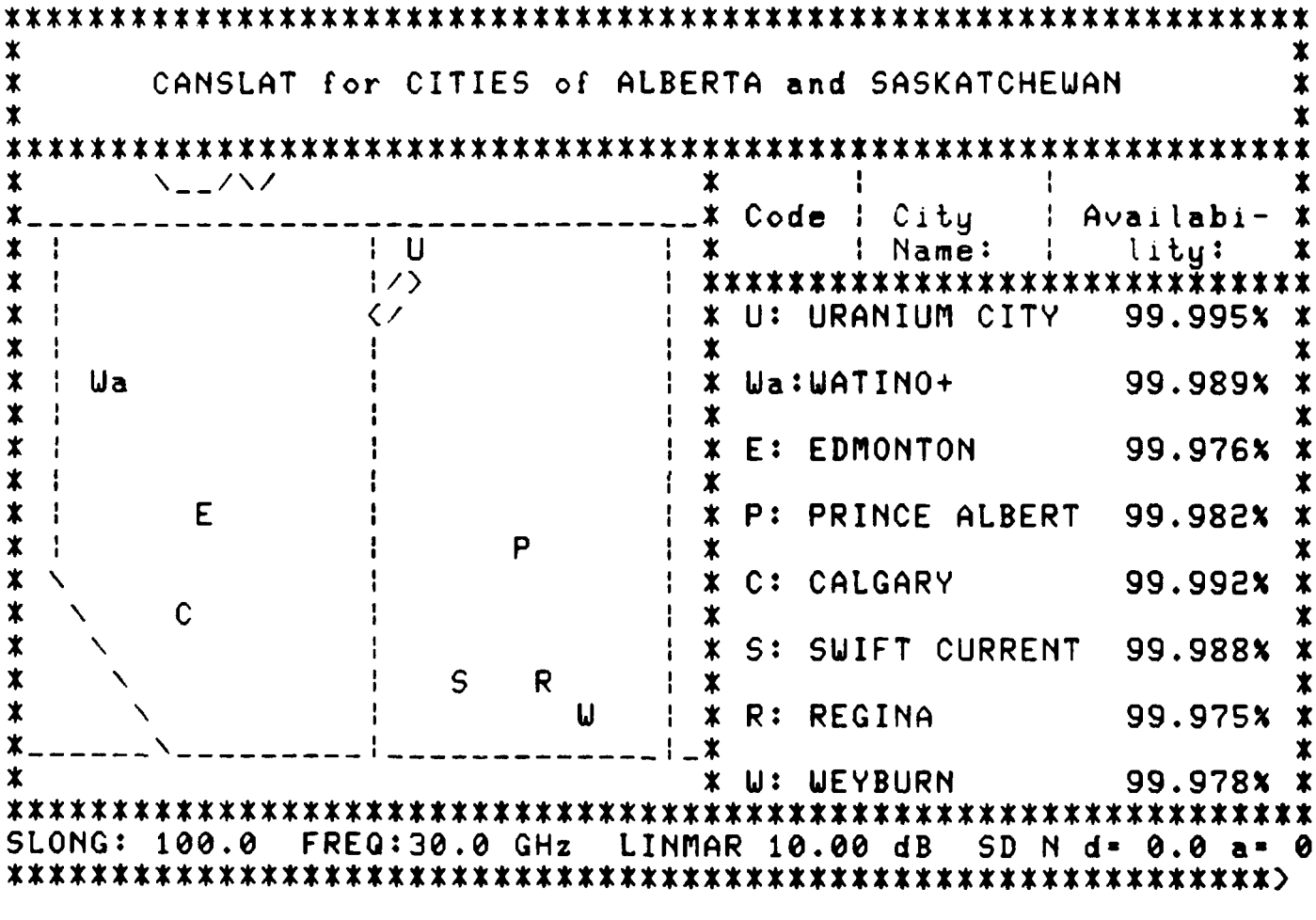

CANSLAT for CITIES of ALBERTA and SASKATCHEWAN
Code | City Name: | Availability:
U: URANIUM CITY 99.995%
Wa:WATINO+ 99.989%
E: EDMONTON 99.976%
P: PRINCE ALBERT 99.982%
C: CALGARY 99.992%
S: SWIFT CURRENT 99.988%
R: REGINA 99.975%
W: WEYBURN 99.978%
U
Wa
E
P
C
S
R
W
SLONG: 100.0 FREQ:30.0 GHz LINMAR 10.00 dB SD N d= 0.0 a= 0

Fig. 87

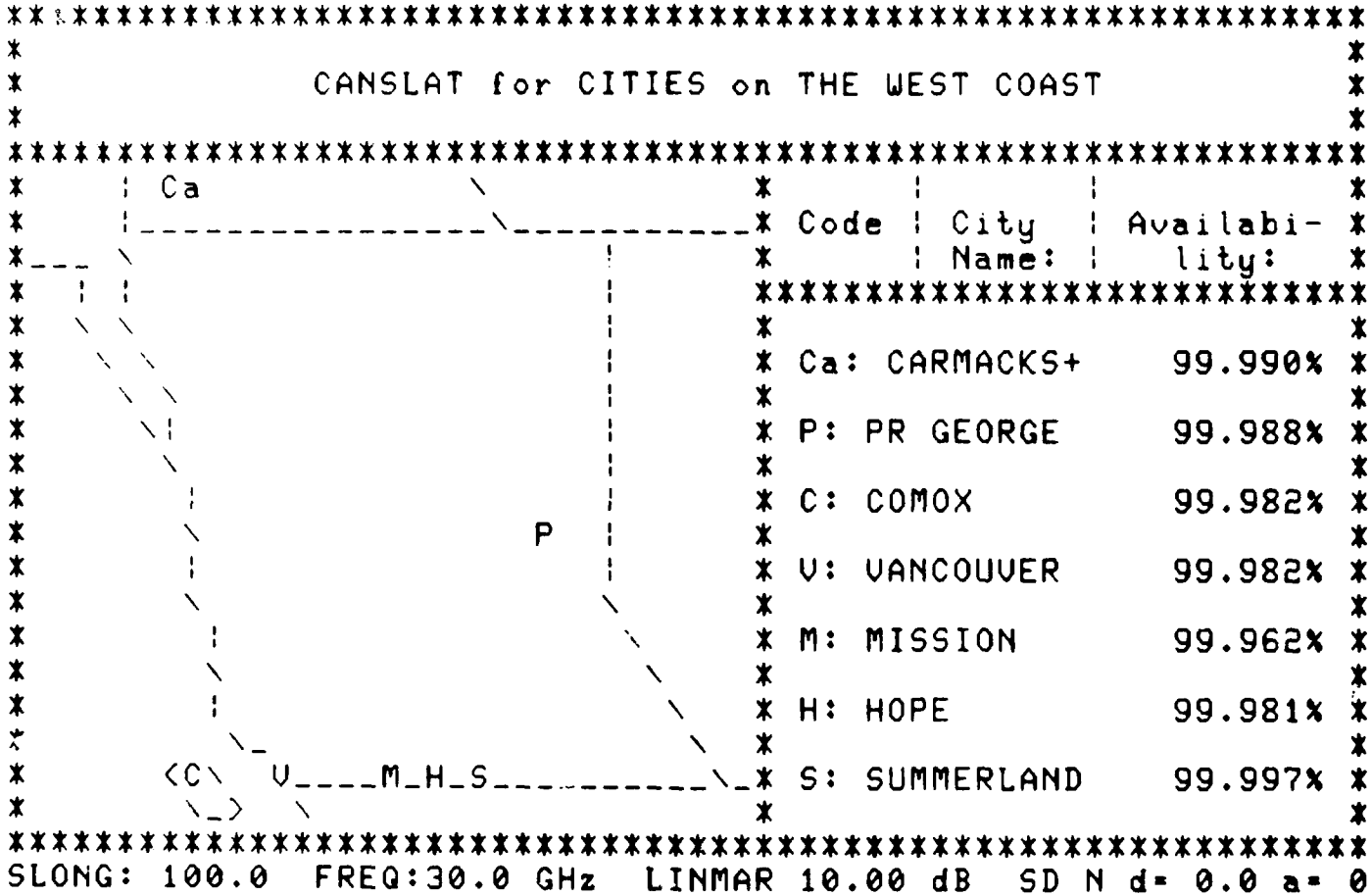

CANSLAT for CITIES on THE WEST COAST
Ca
P
C
V
M
H
S
Code | City Name: | Availability:
Ca: CARMACKS+ 99.990%
P: PR GEORGE 99.988%
C: COMOX 99.982%
V: VANCOUVER 99.982%
M: MISSION 99.962%
H: HOPE 99.981%
S: SUMMERLAND 99.997%
SLONG: 100.0 FREQ:30.0 GHz LINMAR 10.00 dB SD N d= 0.0 a= 0

Fig. 88

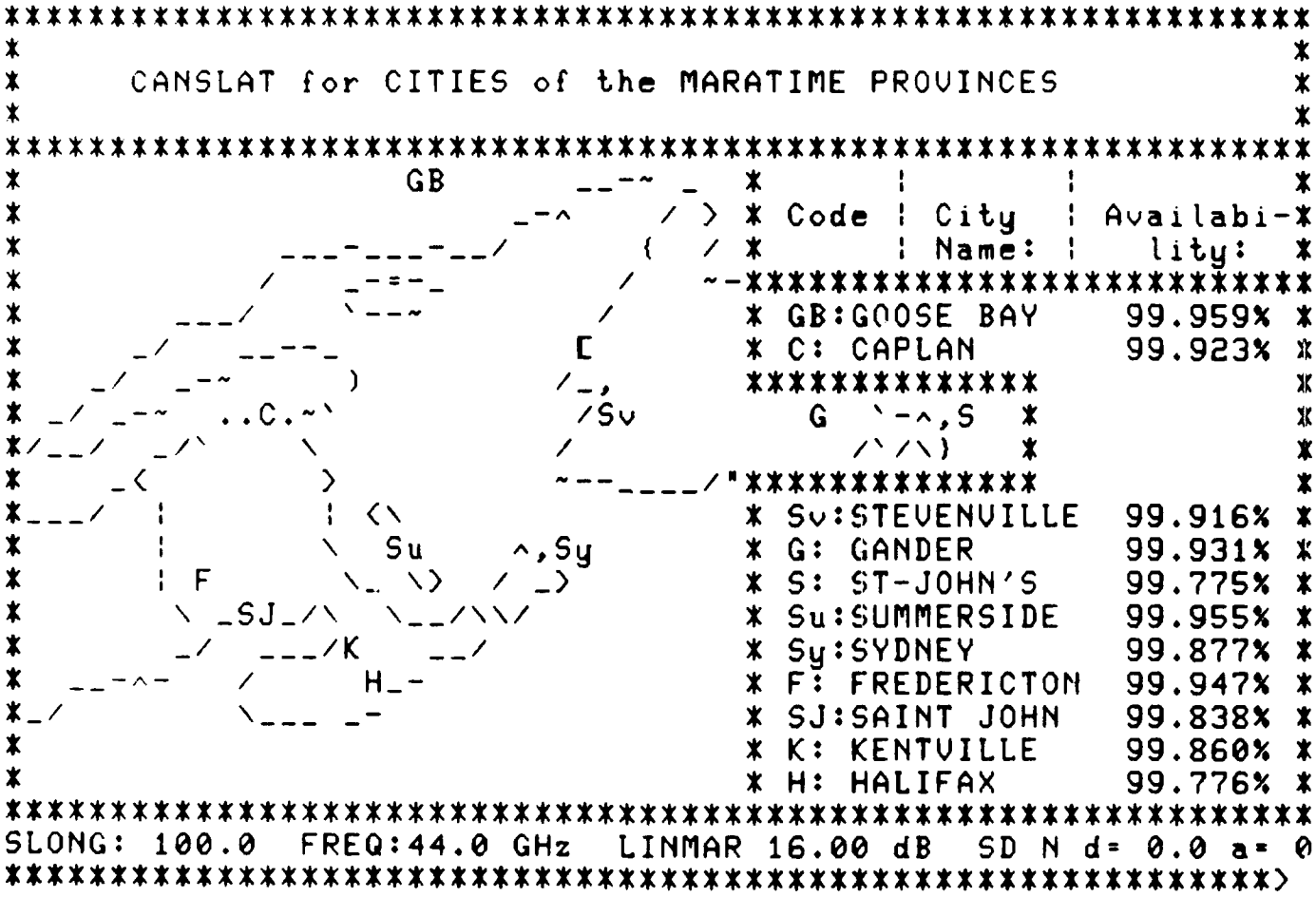

CANSLAT for CITIES of the MARATIME PROVINCES
GB
Sv
G
Su
Sy
F
SJ
K
H
Code | City Name: | Availability:
GB:GOOSE BAY 99.959%
C: CAPLAN 99.923%
Sv:STEVENVILLE 99.916%
G: GANDER 99.931%
S: ST-JOHN'S 99.775%
Su:SUMMERSIDE 99.955%
Sy:SYDNEY 99.877%
F: FREDERICTON 99.947%
SJ:SAINT JOHN 99.838%
K: KENTVILLE 99.860%
H: HALIFAX 99.776%
SLONG: 100.0 FREQ:44.0 GHz LINMAR 16.00 dB SD N d= 0.0 a= 0

Fig. 89

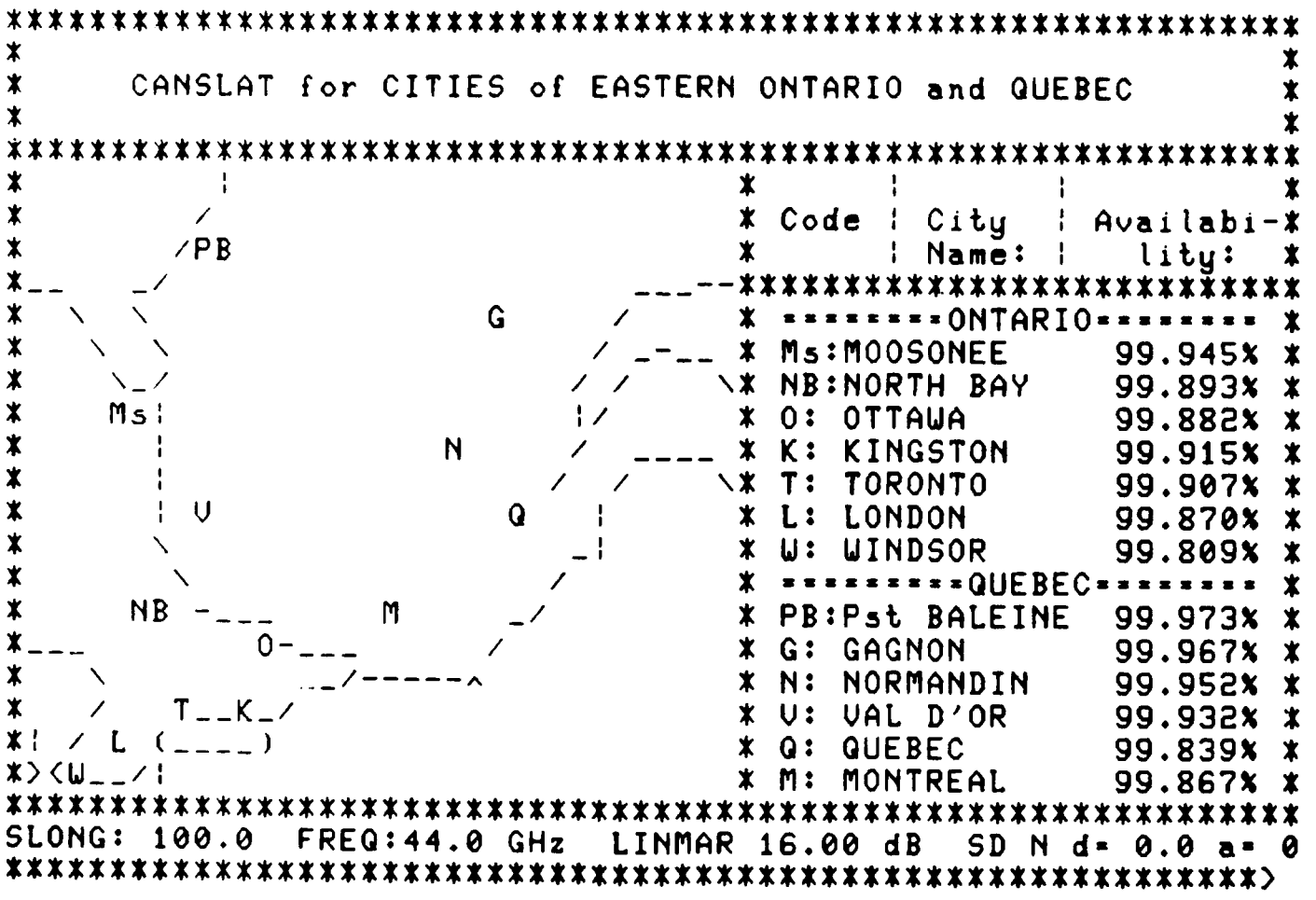

CANSLAT for CITIES of EASTERN ONTARIO and QUEBEC
Code | City Name: | Availability:
ONTARIO
Ms: MOOSONEE 99.945%
NB: NORTH BAY 99.893%
O: OTTAWA 99.882%
K: KINGSTON 99.915%
T: TORONTO 99.907%
L: LONDON 99.870%
W: WINDSOR 99.809%
QUEBEC
PB: Pst BALEINE 99.973%
G: GAGNON 99.967%
N: NORMANDIN 99.952%
V: VAL D'OR 99.932%
Q: QUEBEC 99.839%
M: MONTREAL 99.867%
SLONG: 100.0 FREQ:44.0 GHz LINMAR 16.00 dB SD N d= 0.0 a= 0

Fig. 90

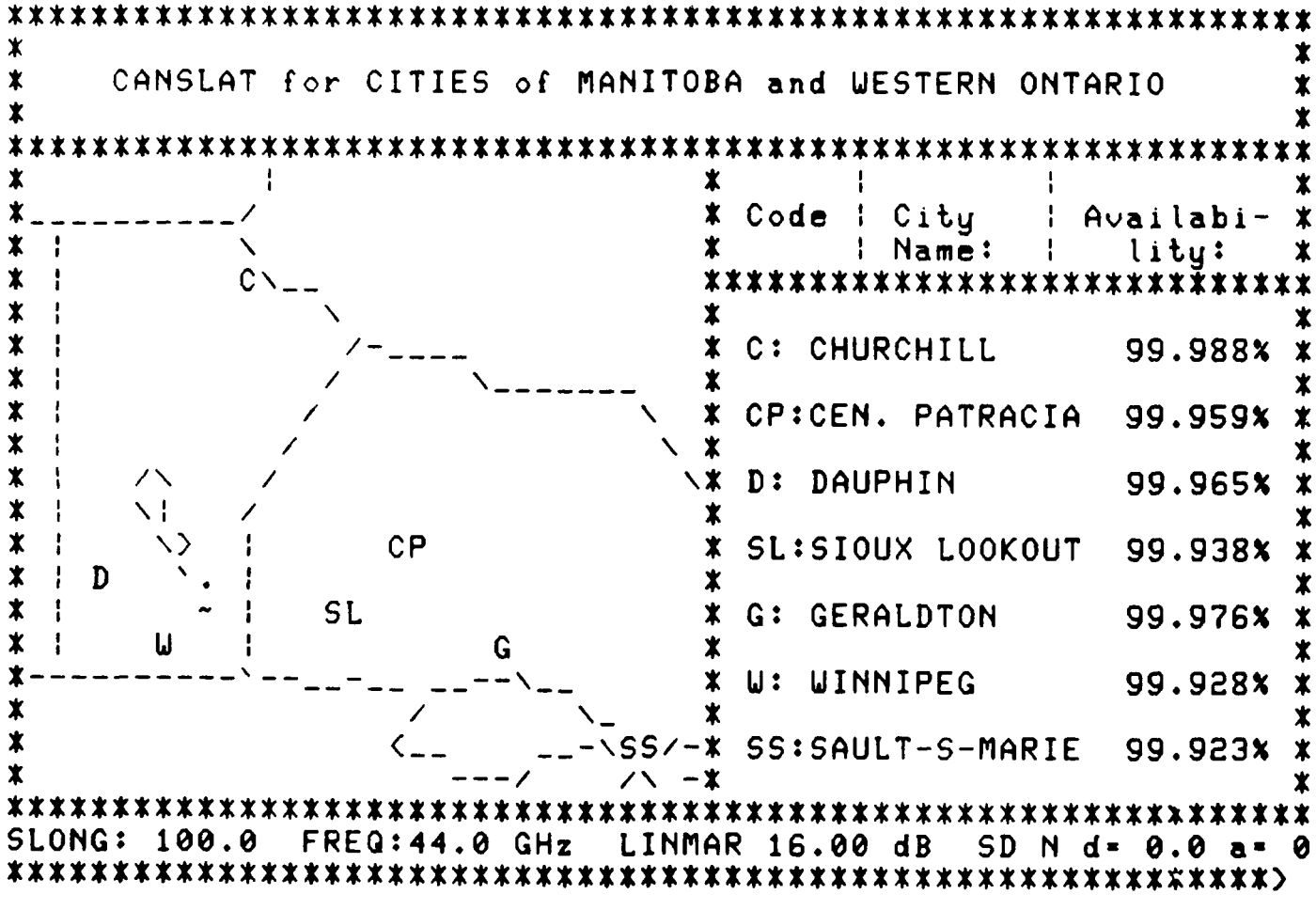

CANSLAT for CITIES of MANITOBA and WESTERN ONTARIO
Code | City Name: | Availability:
C: CHURCHILL 99.988%
CP:CEN. PATRACIA 99.959%
D: DAUPHIN 99.965%
SL:SIOUX LOOKOUT 99.938%
G: GERALDTON 99.976%
W: WINNIPEG 99.928%
SS:SAULT-S-MARIE 99.923%
C
CP
D
SL
W
G
SS
SLONG: 100.0 FREQ:44.0 GHz LINMAR 16.00 dB SD N d= 0.0 a= 0

Fig. 91

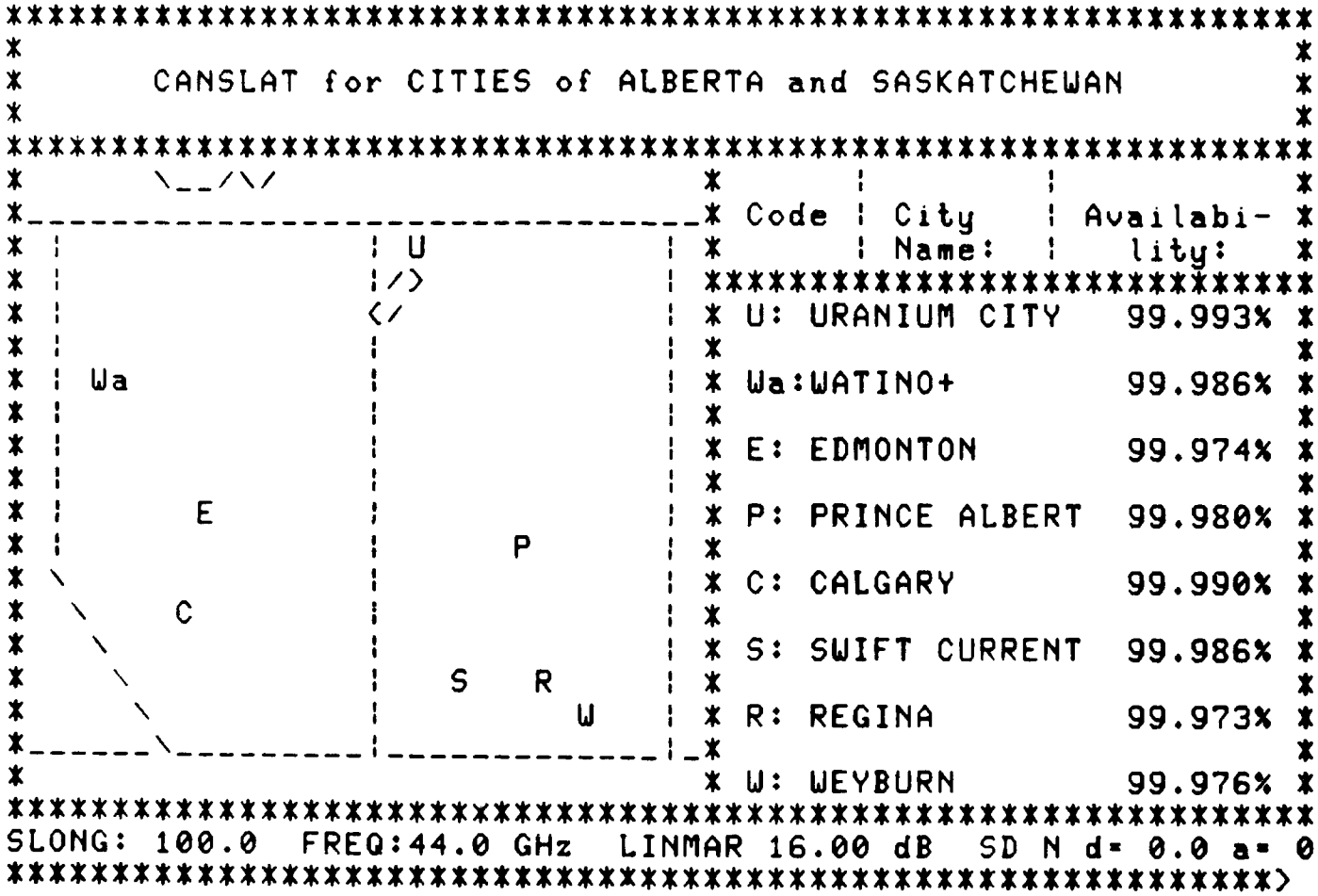
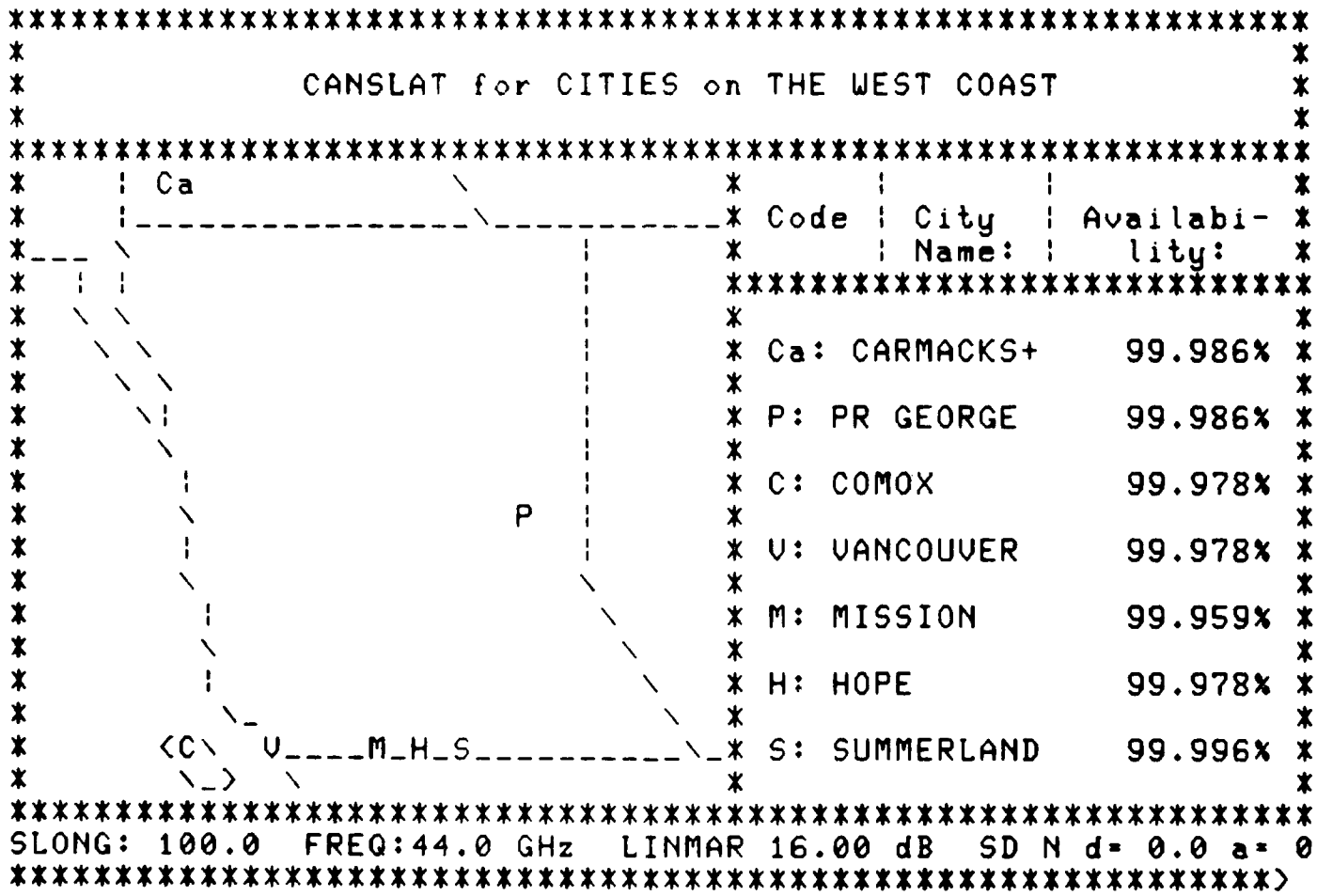

CANSLAT for CITIES of ALBERTA and SASKATCHEWAN
Code
City Name:
Availability:
U: URANIUM CITY 99.993%
Wa:WATINO+ 99.986%
E: EDMONTON 99.974%
P: PRINCE ALBERT 99.980%
C: CALGARY 99.990%
S: SWIFT CURRENT 99.986%
R: REGINA 99.973%
W: WEYBURN 99.976%
SLONG: 100.0 FREQ:44.0 GHz LINMAR 16.00 dB SD N d= 0.0 a= 0

Fig. 92




```
*****************************************************************
*                                                               *
*              CANSLAT for CITIES on THE WEST COAST             *
*                                                               *
*****************************************************************
*    | Ca              \              *      |       |           *
*    |_________________\____________* Code | City  | Availabi- *
*___ \                     |         *      | Name: |   lity:   *
*  | |                     |         ****************************
*  \ \                     |         *                           *
*   \ \                    |         * Ca: CARMACKS+    99.986% *
*    \ \                   |         *                           *
*     \|                   |         * P: PR GEORGE     99.986% *
*      \                   |         *                           *
*       |                  |         * C: COMOX         99.978% *
*       \               P  |         *                           *
*       |                  |         * V: VANCOUVER     99.978% *
*       \                  \         *                           *
*        |                  \        * M: MISSION       99.959% *
*        \                   \       *                           *
*        |                    \      * H: HOPE          99.978% *
*         \_                   \     *                           *
*      <C\  V____M_H_S__________\_* S: SUMMERLAND    99.996% *
*       \_>  \                      *                           *
*****************************************************************
SLONG: 100.0  FREQ:44.0 GHz  LINMAR 16.00 dB  SD N d= 0.0 a= 0
*****************************************************************>
```

Fig. 93

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Defence Research Establishment Ottawa
Department of National Defence
Ottawa, Ontario K1A 0Z4

2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable)

UNCLASSIFIED

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title.)

Link Availability and Rain Attenuation Exceedance Characteristics for EHF Satellite Communications with Arbitrary Link Parameters in Canada (U)

4. AUTHORS (Last name, first name, middle initial)

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5. DATE OF PUBLICATION (month and year of publication of document)

October 1988

6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)

183

6b. NO. OF REFS (total cited in document)

15

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

DREO Report

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address.)

PM EHF SATCOM
Defence Research Establishment Ottawa
Department of National Defence
Ottawa, Ontario K1A 0Z4

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant)

D6470-0459B

9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written)

N/A

10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

DREO REPORT 991

10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

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(U) The rain attenuation exceedance and the corresponding link availability have been calculated for any location in Canada for a Satcom link in the 10-45 GHz range with arbitrary values of the link parameters. Contours, with arbitrary constant values, of these two parameters are also determined for any region in Canada. The effect of site diversity on these results can be studied. The results are presented in different formats to facilitate their use in a system design. The CCIR rain attenuation prediction model, Hodge site diversity model and long term rain statistics have been used for this work. Following a brief review of the subject, representative rain attenuation exceedance and link availability results are given for a Satcom link at 20, 30 and 44 GHz for a few selected values of the link parameters. From the point of view of rain attenuation, this study indicates the feasibility of a 20-44 GHz Satcom system for Canada with ~ 99.5% link availability.

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